MODIS NDVI trend in Iceland

Martha Raynolds, University of Alaska Fairbanks
Borgþór Magnússon, Sigmar Metúsalemsson, Sigurður H. Magnússon
Iceland Institute of Natural History

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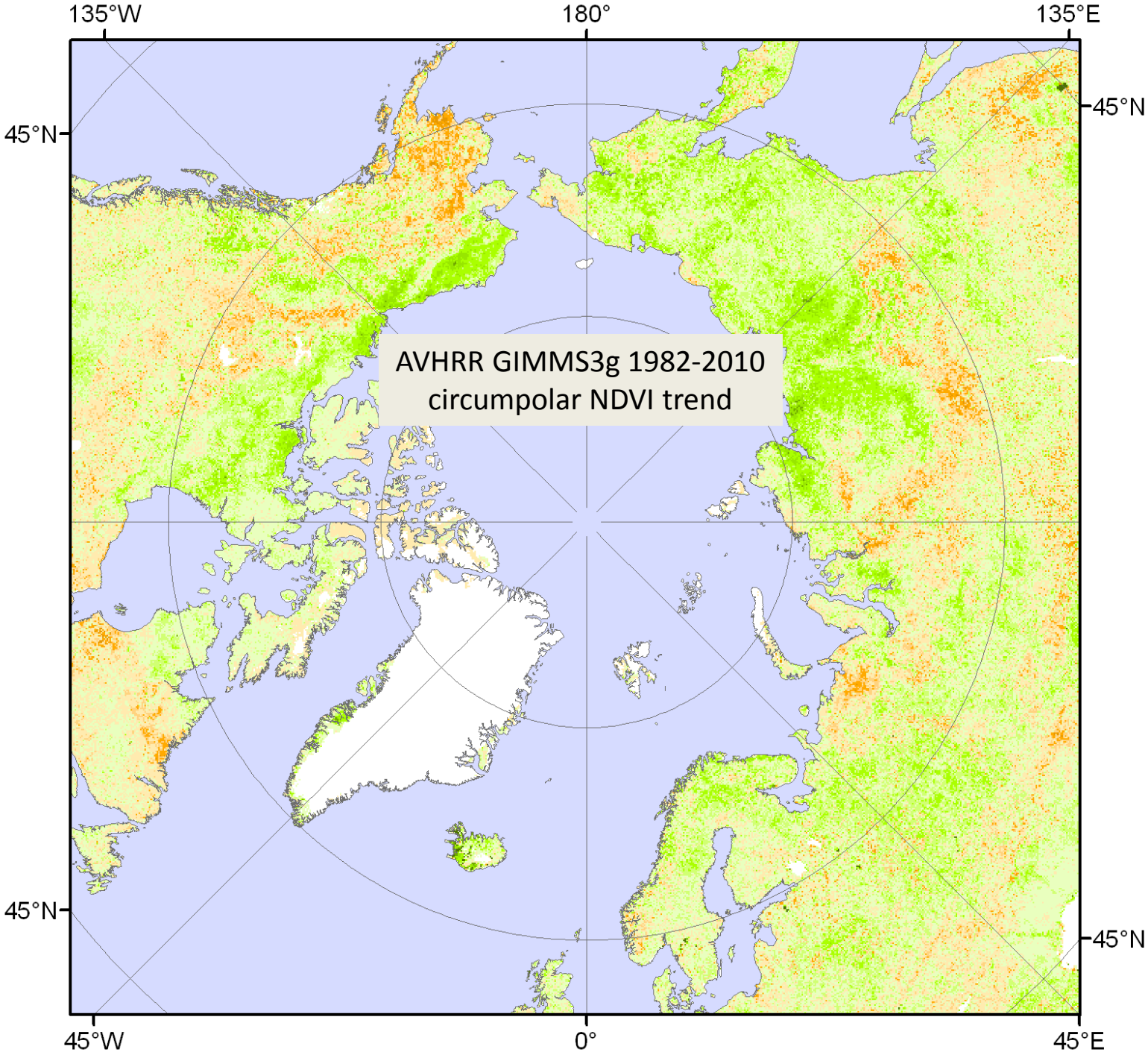
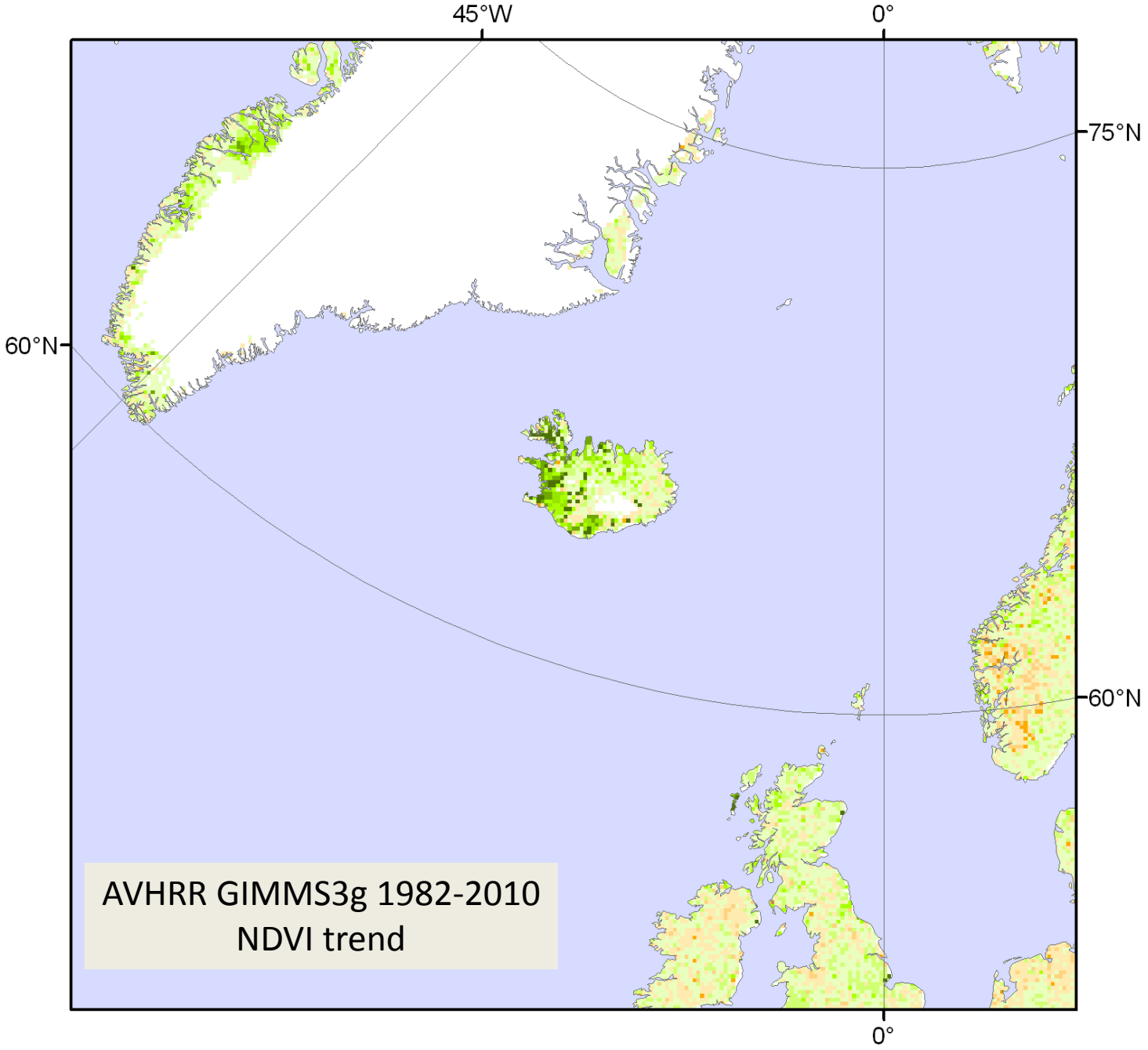
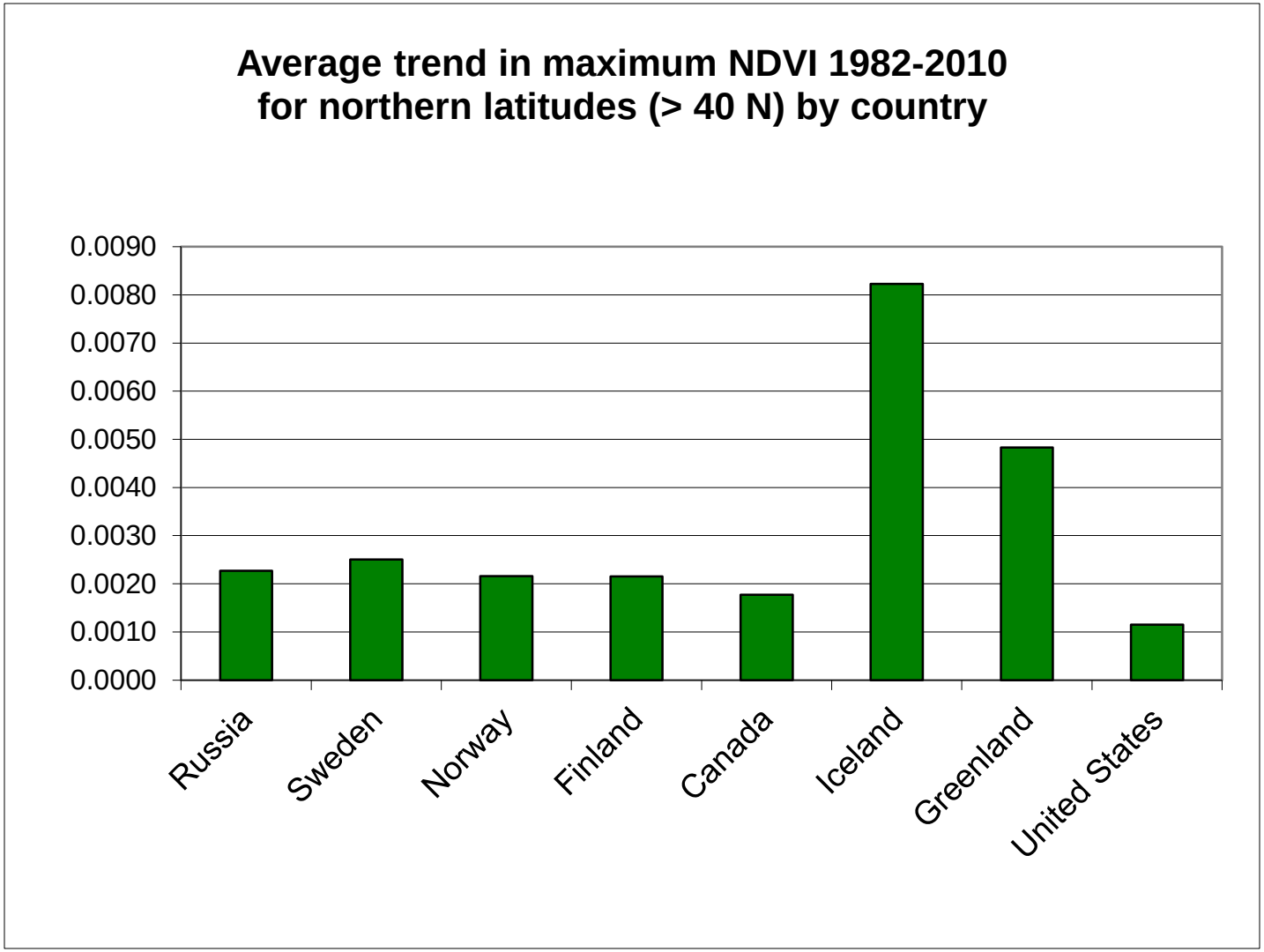
In 2011, I was analyzing trends in circumpolar arctic NDVI using the longest continuous time trend available, AVHRR GIMMS data.

I was especially interested in Iceland because I was living in Akureyri that year, as a Fulbright Scholar.

We ran into issues with the AVHRR data, and I am now following up with a MODIS analysis

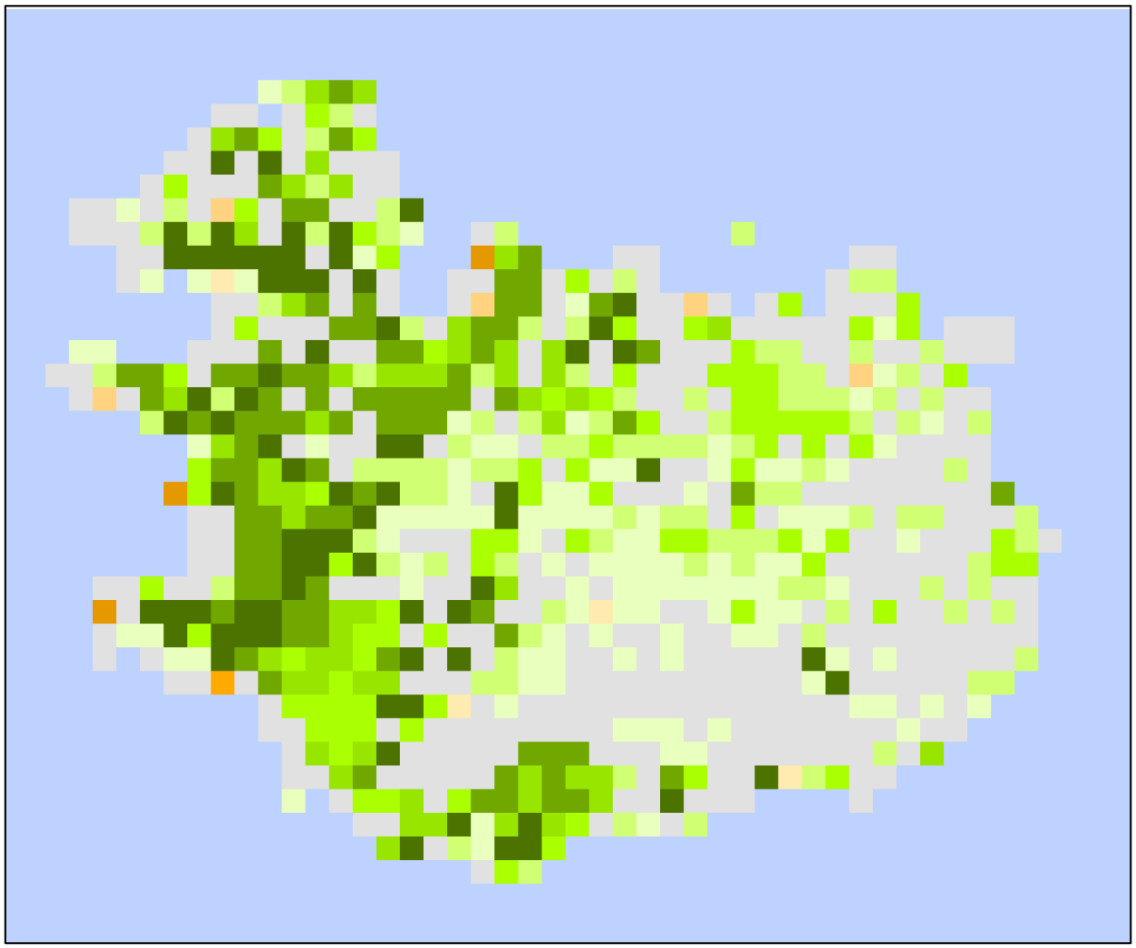

AVHRR GIMMS3g 1982-2010
circumpolar NDVI trend
135°W
180°
135°E
45°N
45°N
45°N
45°N
45°W
0°
45°E

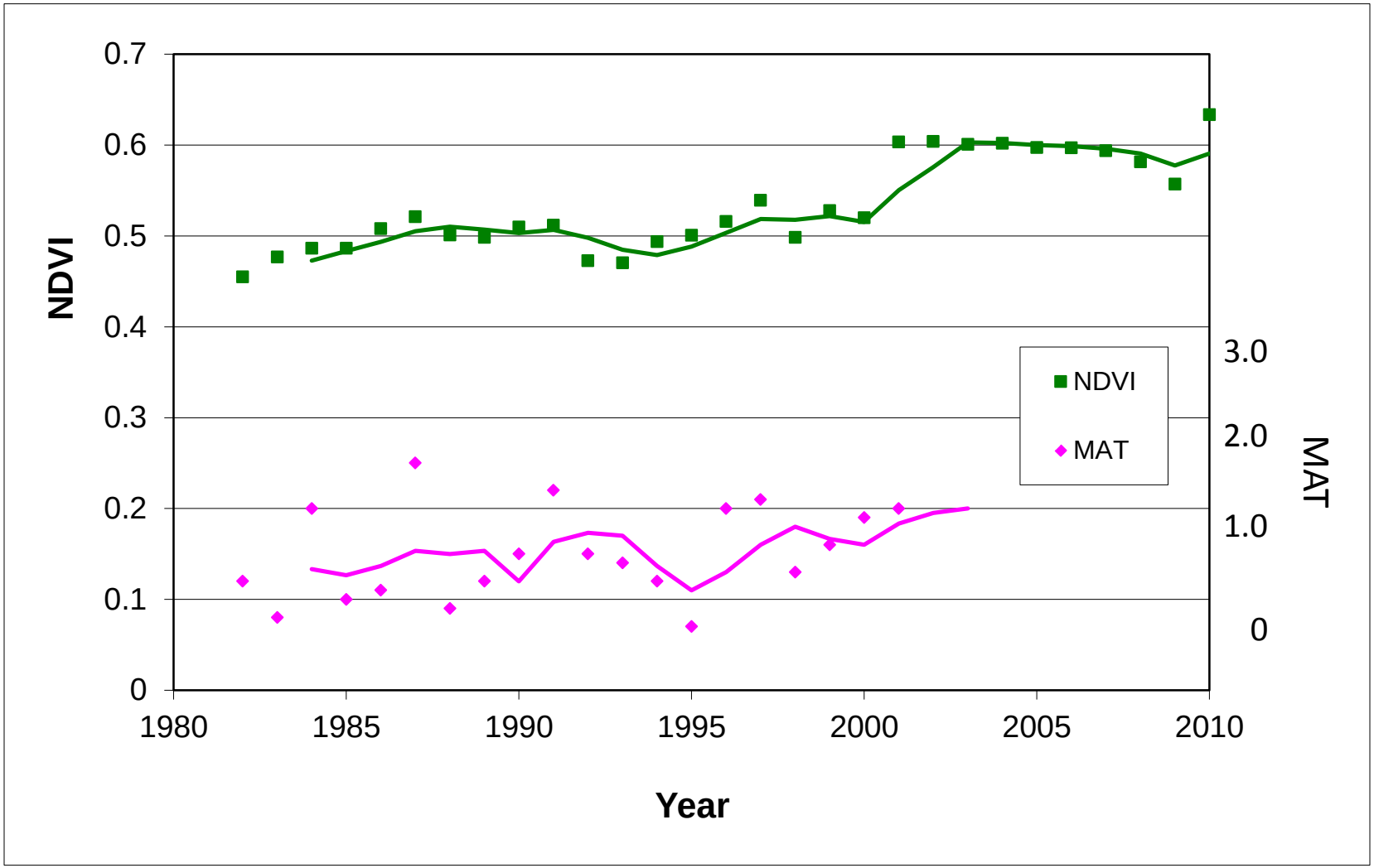

45°W
0°
75°N
60°N
60°N
0°
AVHRR GIMMS3g 1982-2010
NDVI trend


Average trend in maximum NDVI 1982-2010
for northern latitudes (> 40 N) by country
0.0090
0.0080
0.0070
0.0060
0.0050
0.0040
0.0030
0.0020
0.0010
0.0000
Russia
Sweden
Norway
Finland
Canada
Iceland
Greenland
United States

Change in biomass (kg/m2/yr)

- > 0.02
- 0.015 - 0.02
- 0.01 - 0.015
- 0.005 - 0.01
- 0.0025 - 0.005
- 0 - 0.0025
- -0.0025 - 0
- -0.005 - -0.0025
- -0.01 - -0.005
- < -0.01
- not sign. rate of change

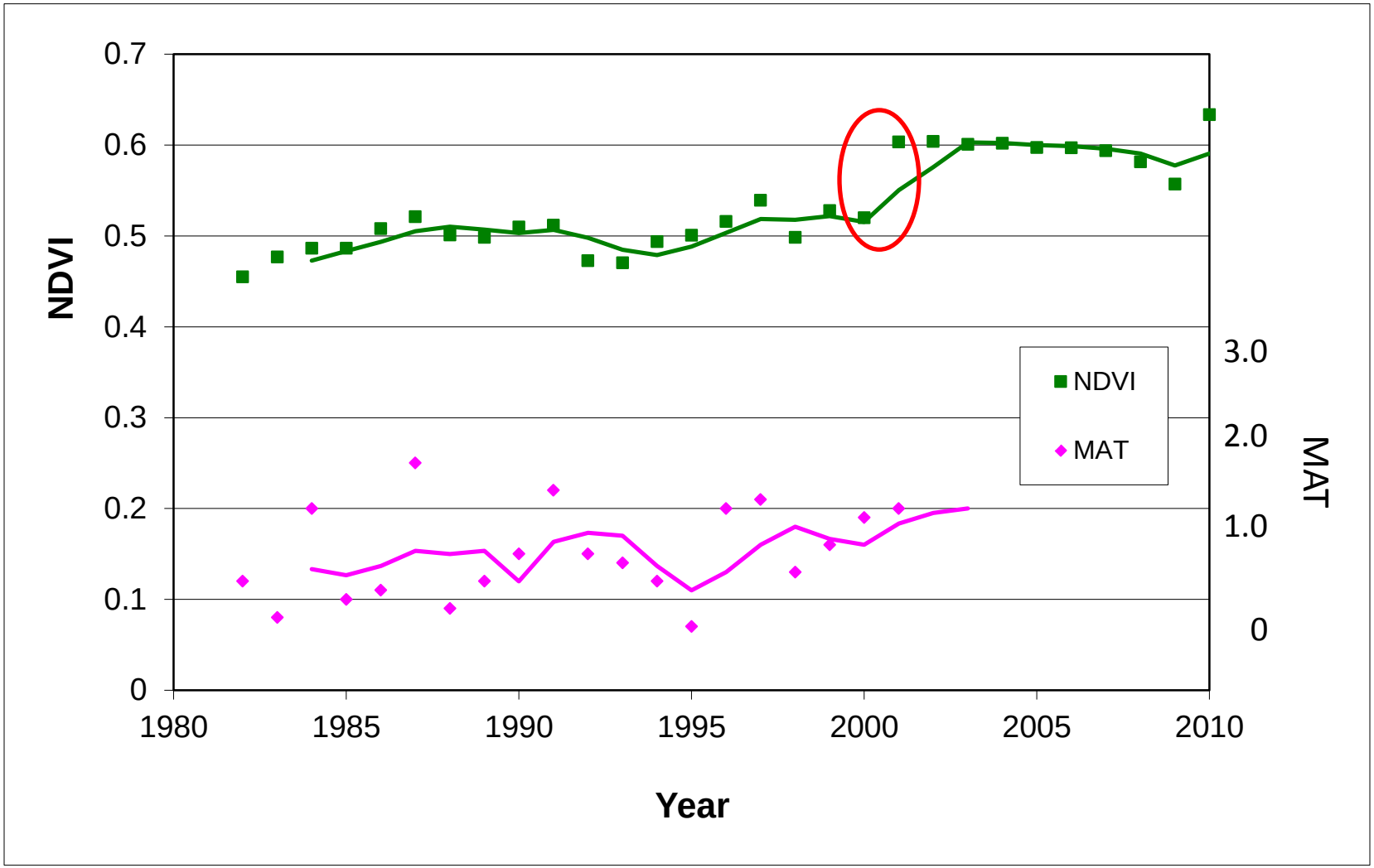




AVHRR GIMMS3g NDVI

Mean Annual Temperature for Iceland from Nawri & Bjornsson 2010, Fig. 14 ERA-40 Reanalysis

Jump in NDVI between 2000 and 2001 likely due to a change in satellites and AVHRR sensors from NOAA-14 to NOAA-16 and NOAA AVHRR/2 to NOAA AVHRR/3



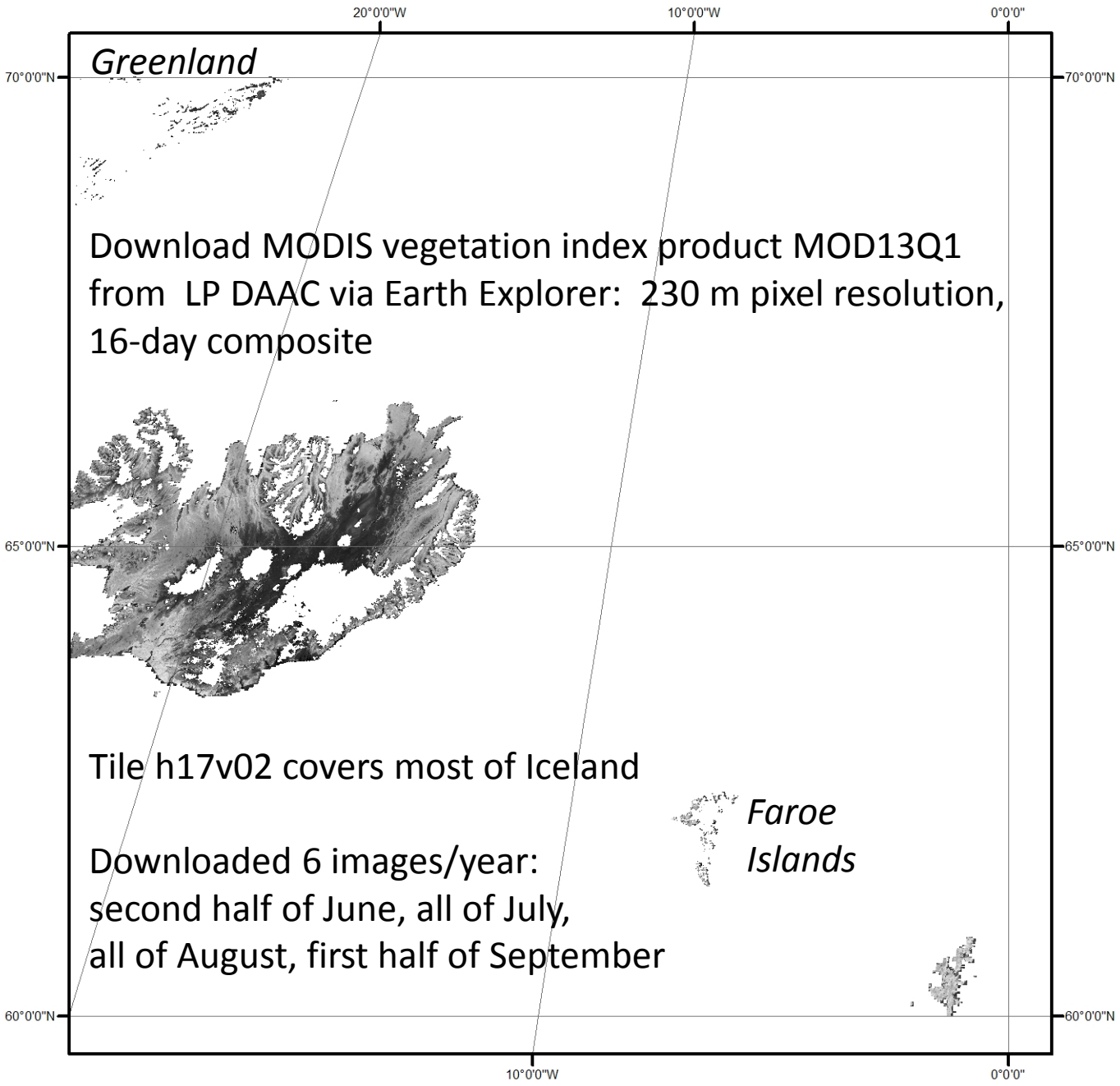
AVHRR GIMMS3g NDVI

Mean Annual Temperature for Iceland from Nawri & Bjornsson 2010, Fig. 14 ERA-40 Reanalysis

Thymus praecox

Data Acquisition

Download MODIS vegetation index product MOD13Q1 from LP DAAC via Earth Explorer: 250 m pixel resolution, 16-day composite



Download MODIS vegetation index product MOD13Q1 from LP DAAC via Earth Explorer: 230 m pixel resolution, 16-day composite

Tile h17v02 covers most of Iceland

Downloaded 6 images/year:
second half of June, all of July,
all of August, first half of September

Processing

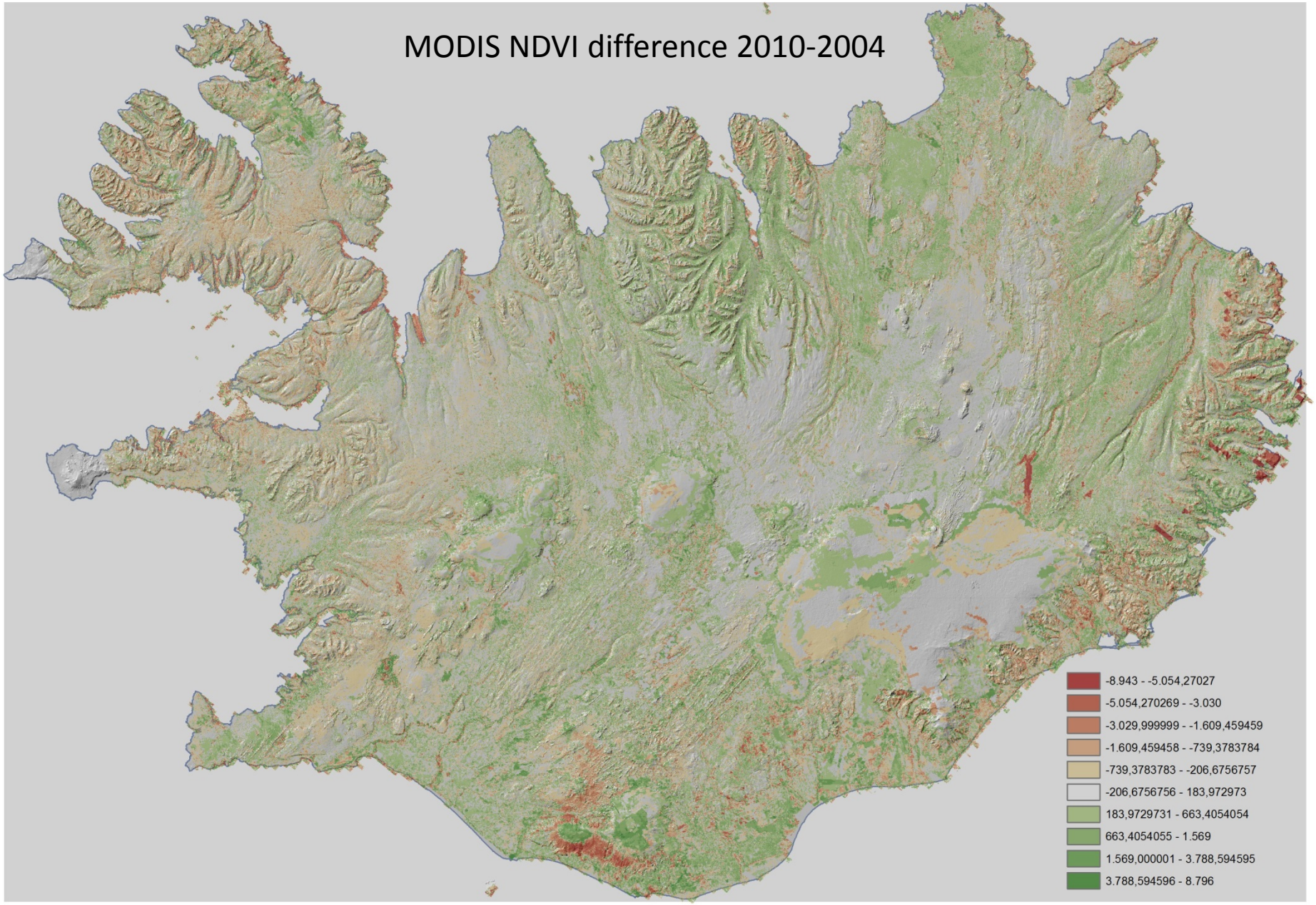
1. Quality control:
   Kept only Pixel Reliability = 0 or 1. Deleted all pixels with -1, 2, 3, 4 reliability values.

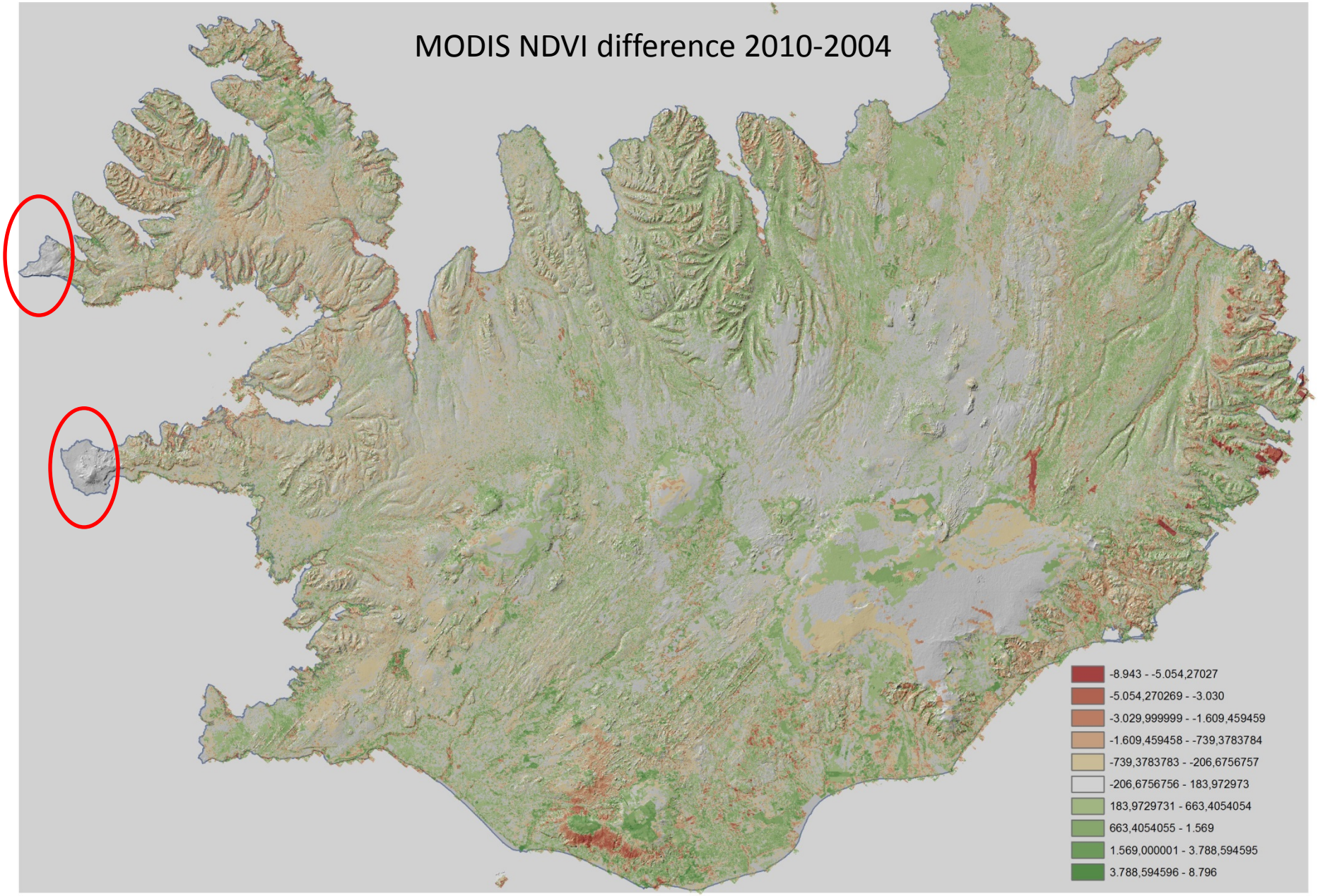
2. Calculated maximum NDVI for each year

3. Calculate linear NDVI trend using R

4. Trimmed MODIS coverage using coastline

5. $p < 0.05$ cutoff


MODIS NDVI difference 2010-2004
-8.943 - -5.054,27027
-5.054,270269 - -3.030
-3.029,999999 - -1.609,459459
-1.609,459458 - -739,3783784
-739,3783783 - -206,6756757
-206,6756756 - 183,972973
183,9729731 - 663,4054054
663,4054055 - 1.569
1.569,000001 - 3.788,594595
3.788,594596 - 8.796


MODIS NDVI difference 2010-2004
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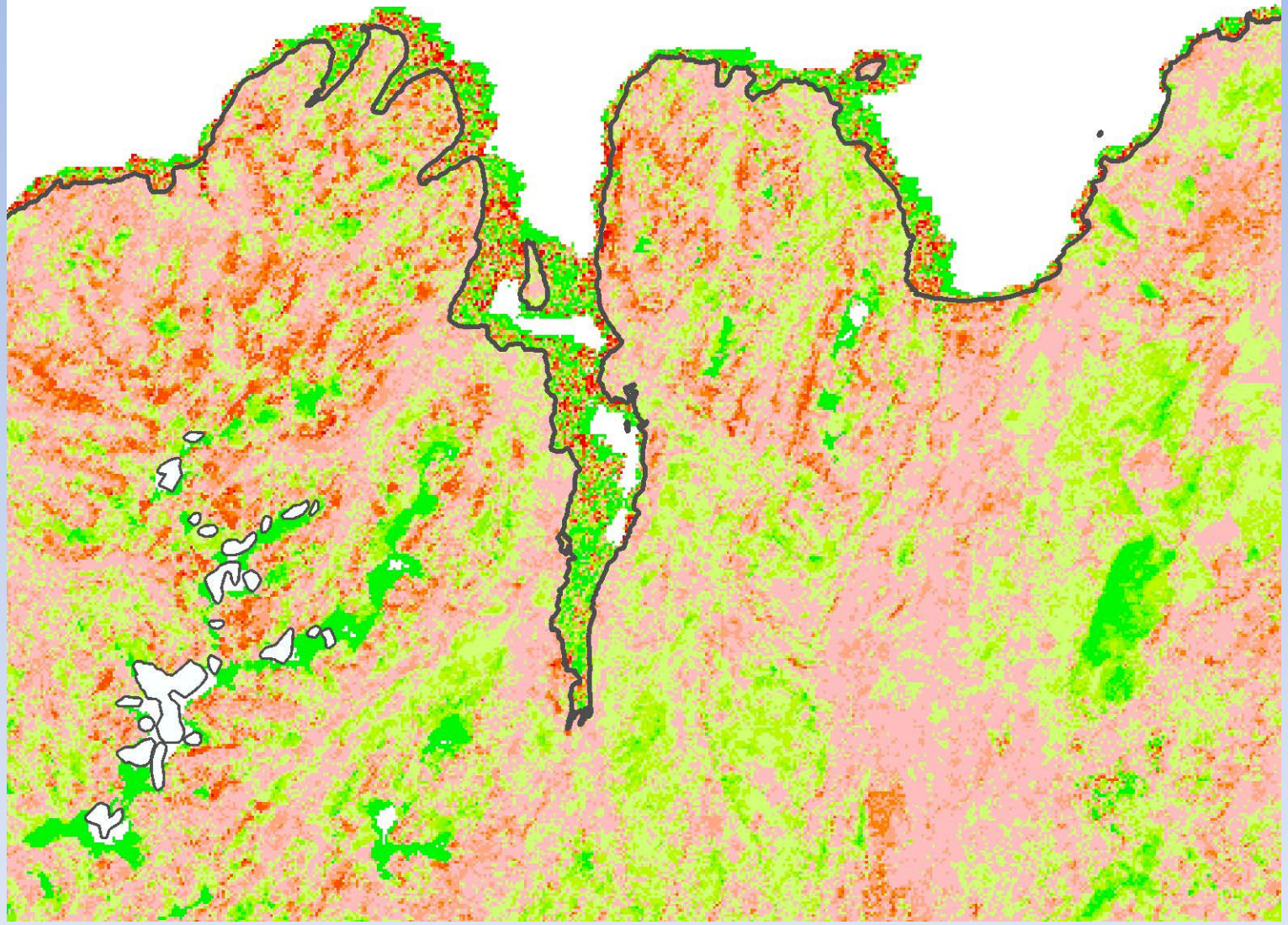
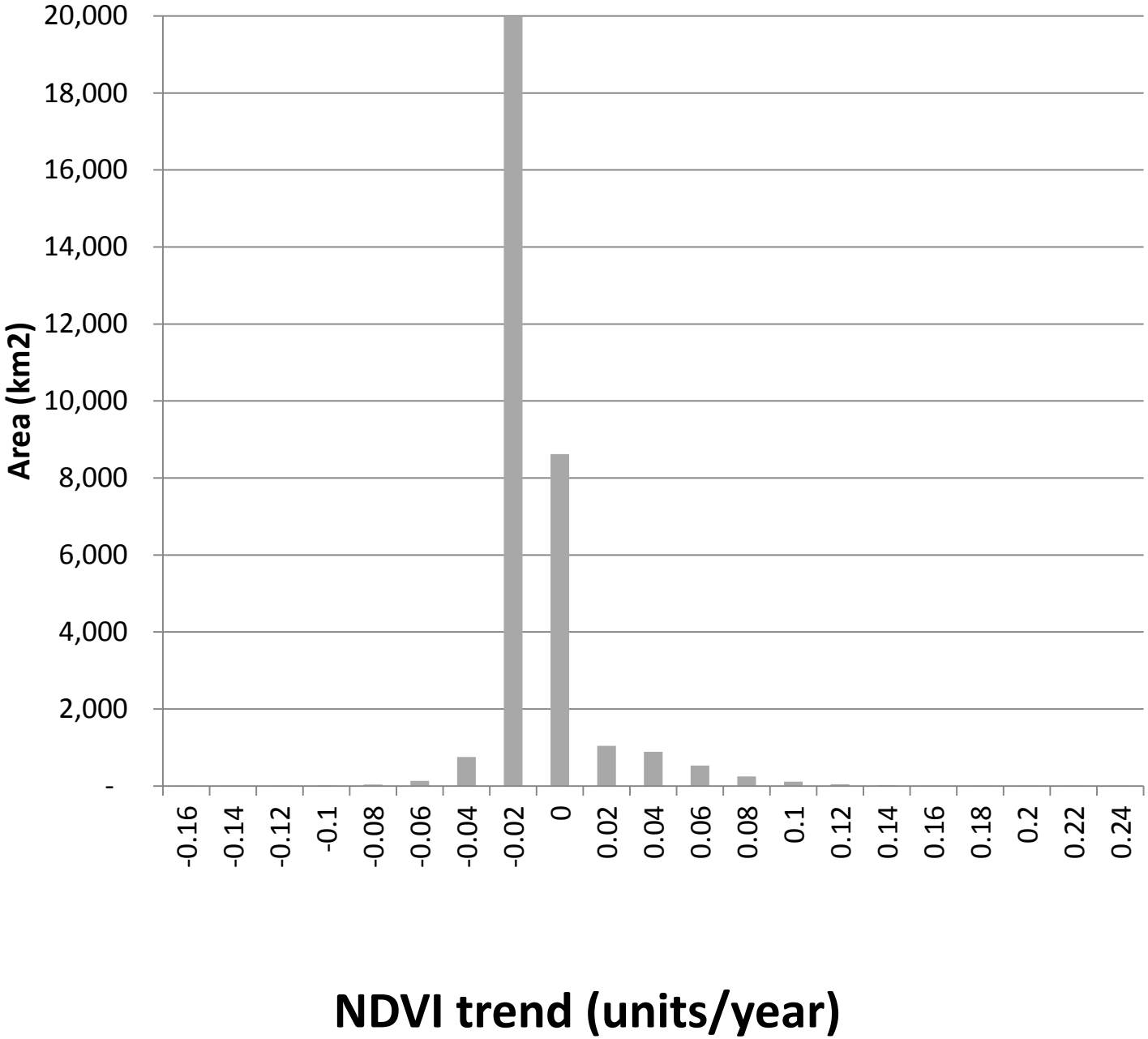
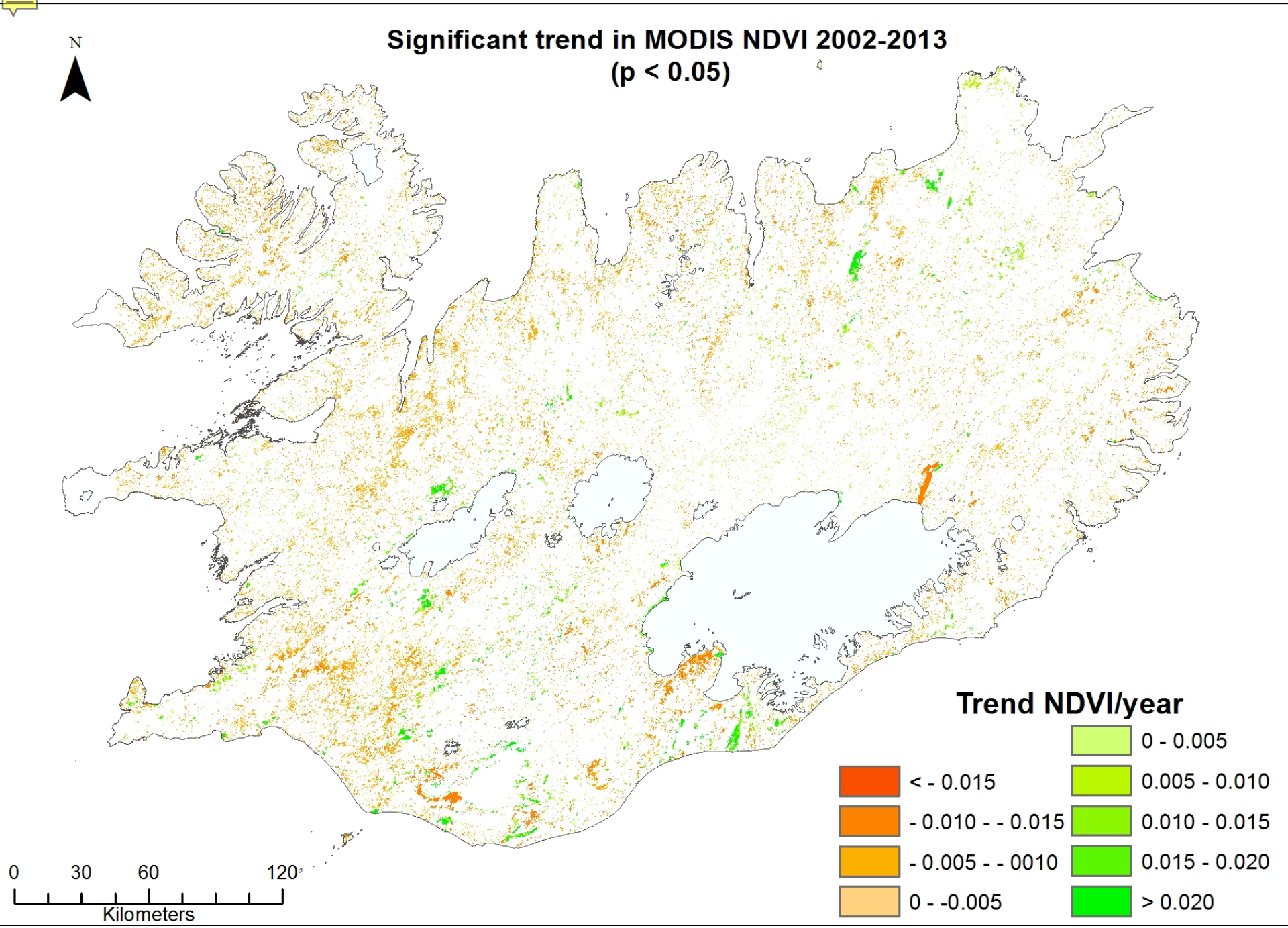
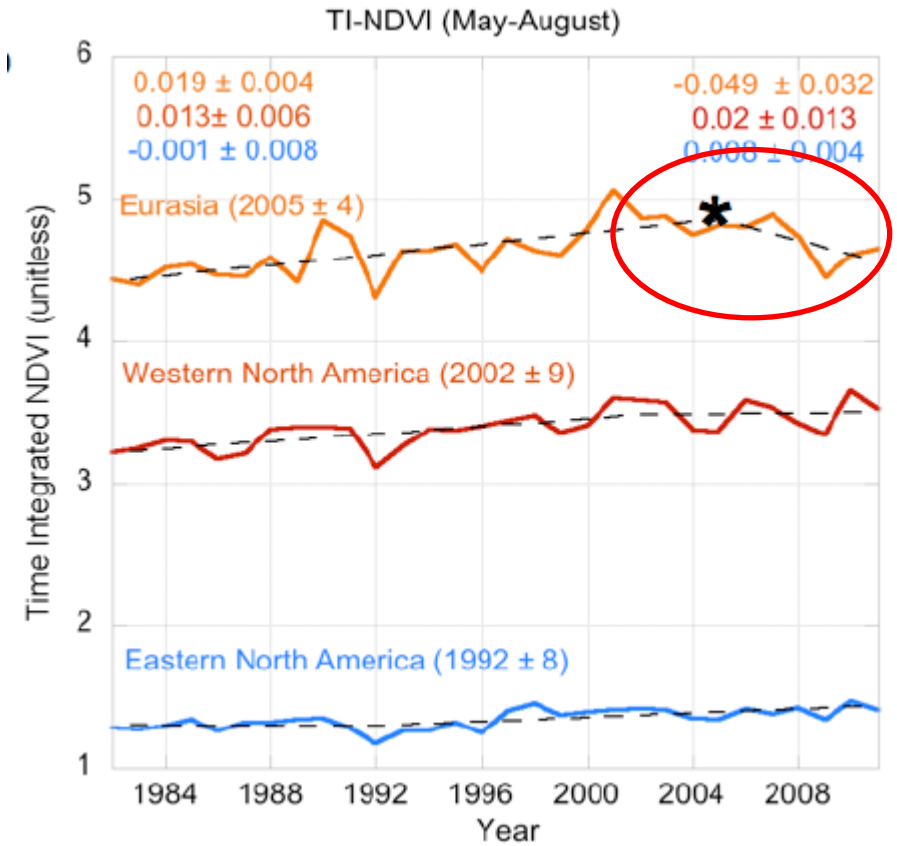
-739,3783783 - -206,6756757
-206,6756756 - 183,972973
183,9729731 - 663,4054054
663,4054055 - 1.569
1.569,000001 - 3.788,594595
3.788,594596 - 8.796

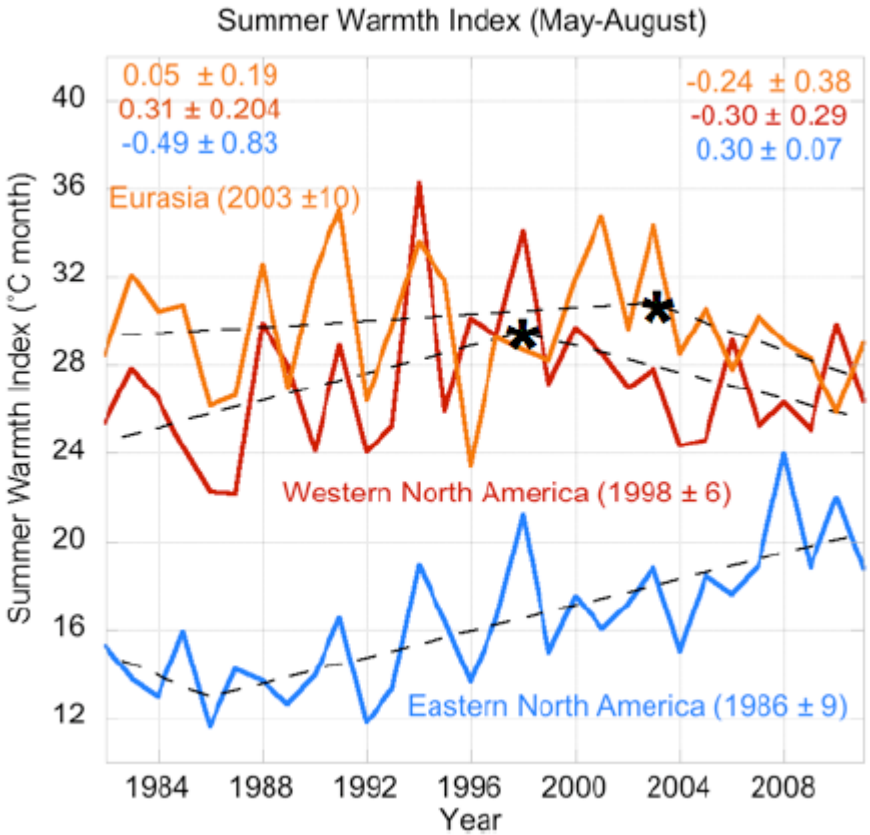
Trim coastline




20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
Area (km2)
-0.16
-0.14
-0.12
-0.1
-0.08
-0.06
-0.04
-0.02
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
0.22
0.24
NDVI trend (units/year)


Significant trend in MODIS NDVI 2002-2013
(p < 0.05)
N
Trend NDVI/year
< - 0.015
- 0.010 - - 0.015
- 0.005 - - 0010
0 - -0.005
0 - 0.005
0.005 - 0.010
0.010 - 0.015
0.015 - 0.020
> 0.020
0
30
60
120
Kilometers



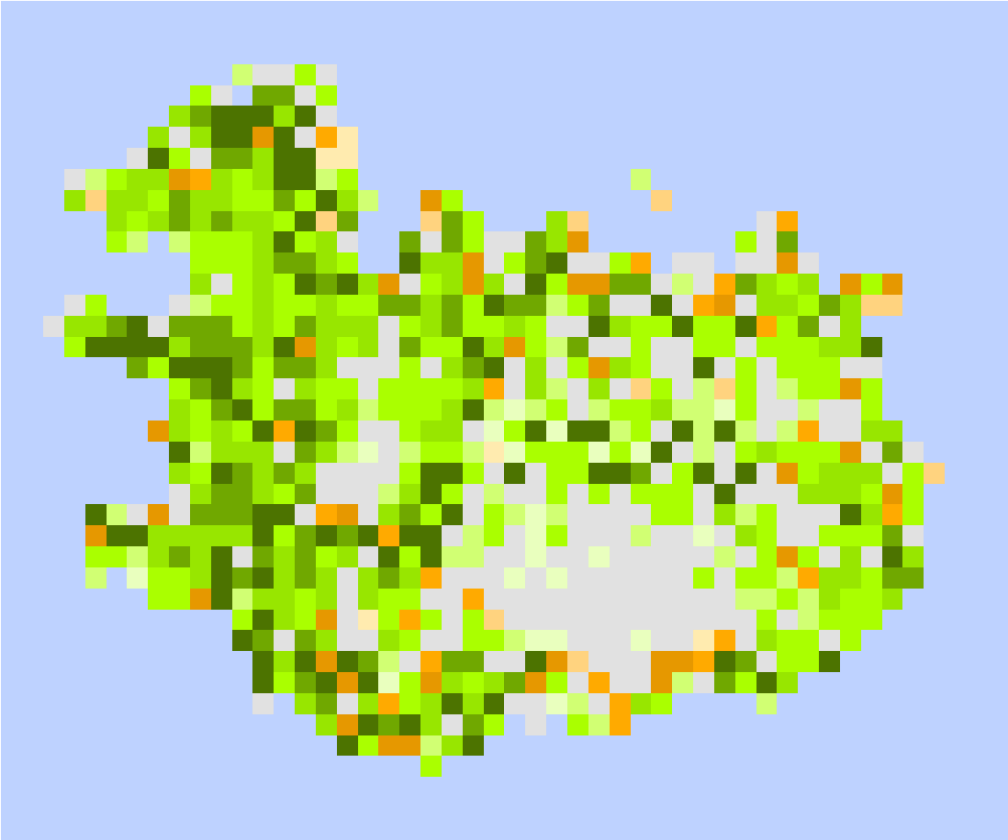


Bhatt et al. 2013. Recent declines in warming and vegetation greening trends over pan-Arctic tundra. Remote Sensing *5*:4229-4254. doi:10.3390/rs5094229.

1982-1989

Change in biomass (kg/m2/yr)

- > 0.02
- 0.015 - 0.02
- 0.01 - 0.015
- 0.005 - 0.01
- 0.0025 - 0.005
- 0 - 0.0025
- -0.0025 - 0
- -0.005 - -0.0025
- -0.01 - -0.005
- < -0.01
- not sign. rate of change



AVHRR GIMMS3g NDVI

1990-1999

Change in biomass (kg/m2/yr)

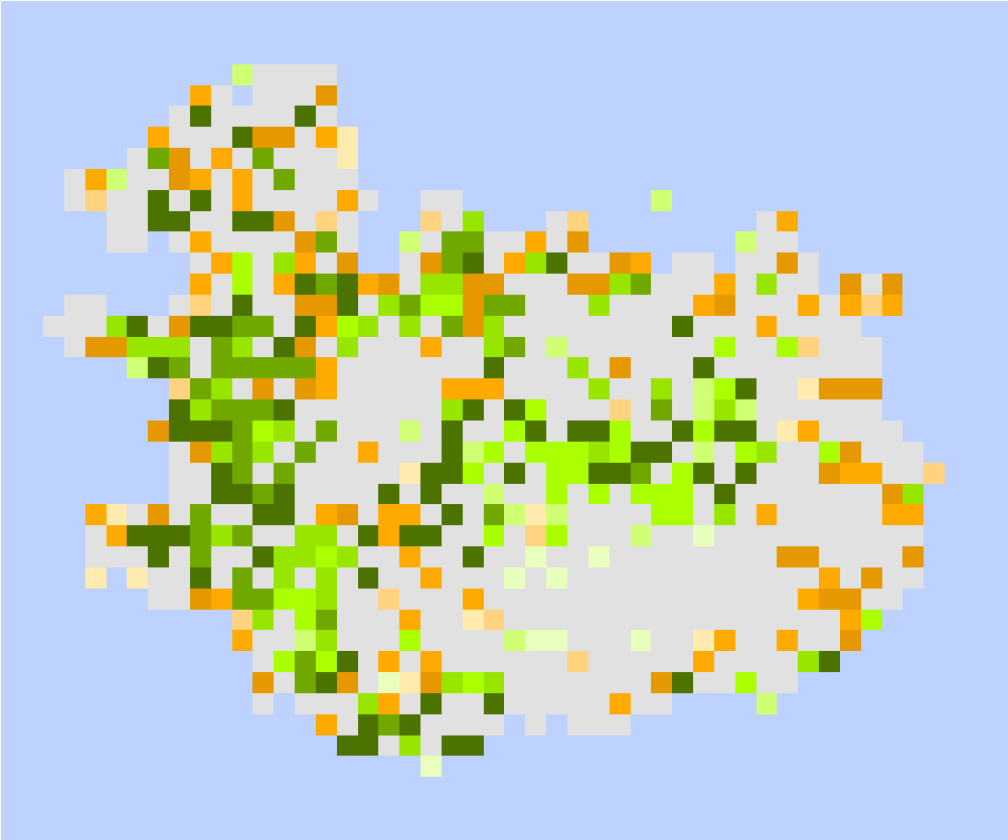
- > 0.02
- 0.015 - 0.02
- 0.01 - 0.015
- 0.005 - 0.01
- 0.0025 - 0.005
- 0 - 0.0025
- -0.0025 - 0
- -0.005 - -0.0025
- -0.01 - -0.005
- < -0.01
- not sign. rate of change

AVHRR GIMMS3g NDVI

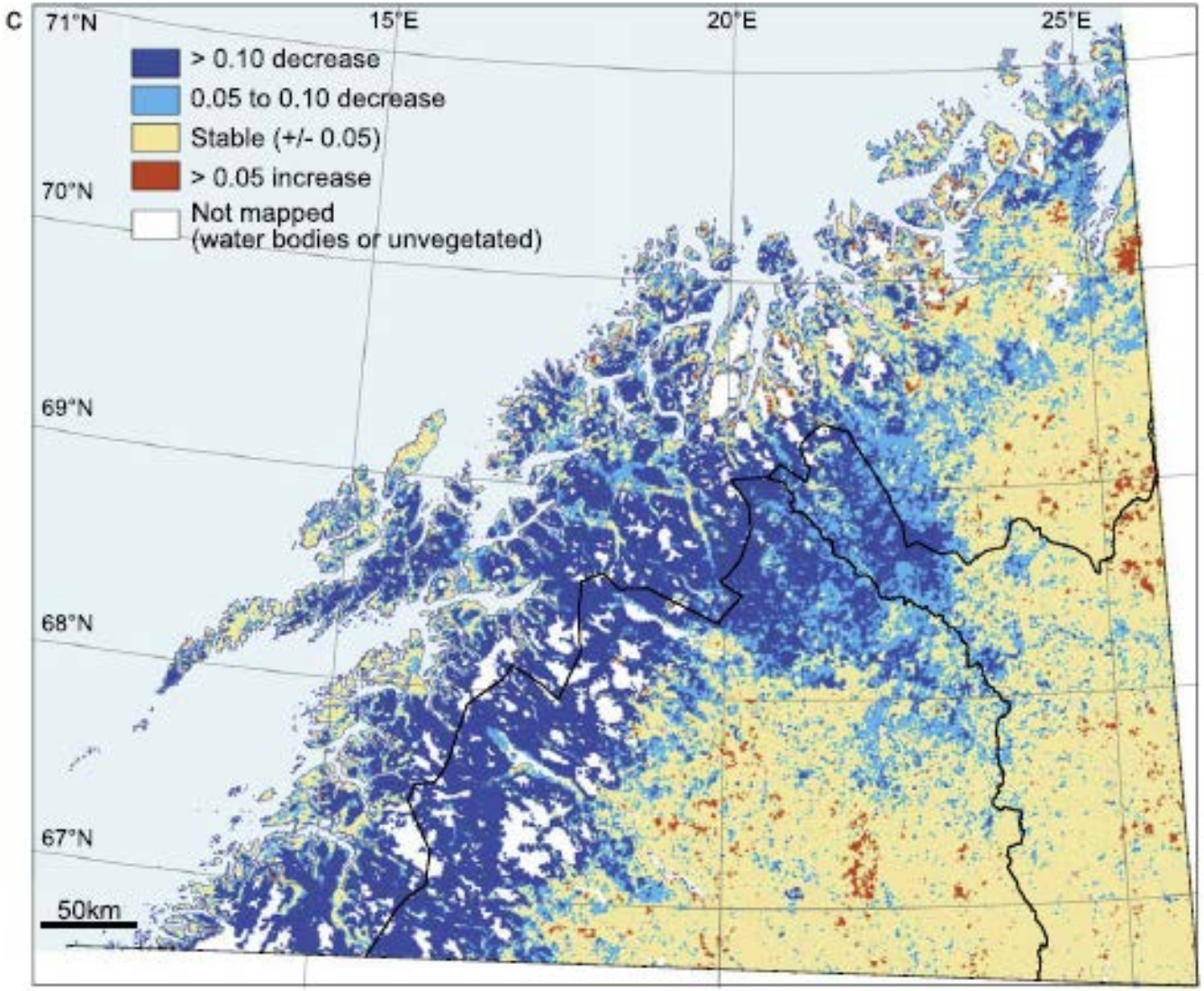
2000-2010

Change in biomass (kg/m2/yr)

- > 0.02
- 0.015 - 0.02
- 0.01 - 0.015
- 0.005 - 0.01
- 0.0025 - 0.005
- 0 - 0.0025
- -0.0025 - 0
- -0.005 - -0.0025
- -0.01 - -0.005
- < -0.01
- not sign. rate of change



AVHRR GIMMS3g NDVI



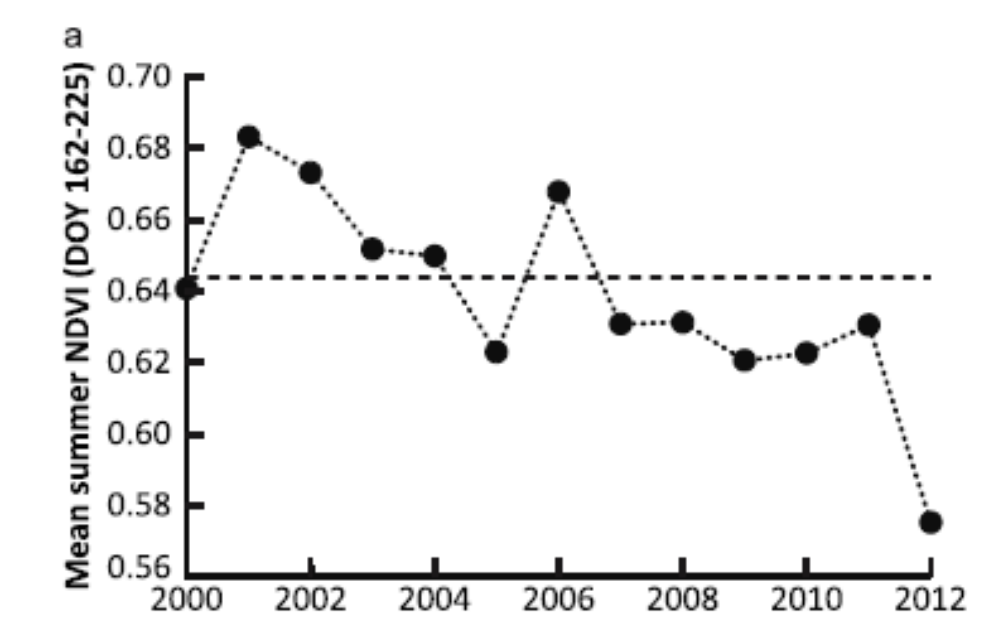
Bjerke J.W., Karlsen S.R., Hogda K.A., Malnes E., Jepsen J.U., Lovibond S., Vikhamar-Schuler D. & Tommervik H. (2014) Record-low primary productivity and high plant damage in the Nordic Arctic Region in 2012 caused by multiple weather events and pest outbreaks. *Environmental Research Letters, 9, 084006*

Anomalous weather events 2011-2012

- Warm autumn temperatures
- Fluctuating winter temperatures
- Cold summer (including frosts)
- Deep snow persisting
- Summer flood and salt spray

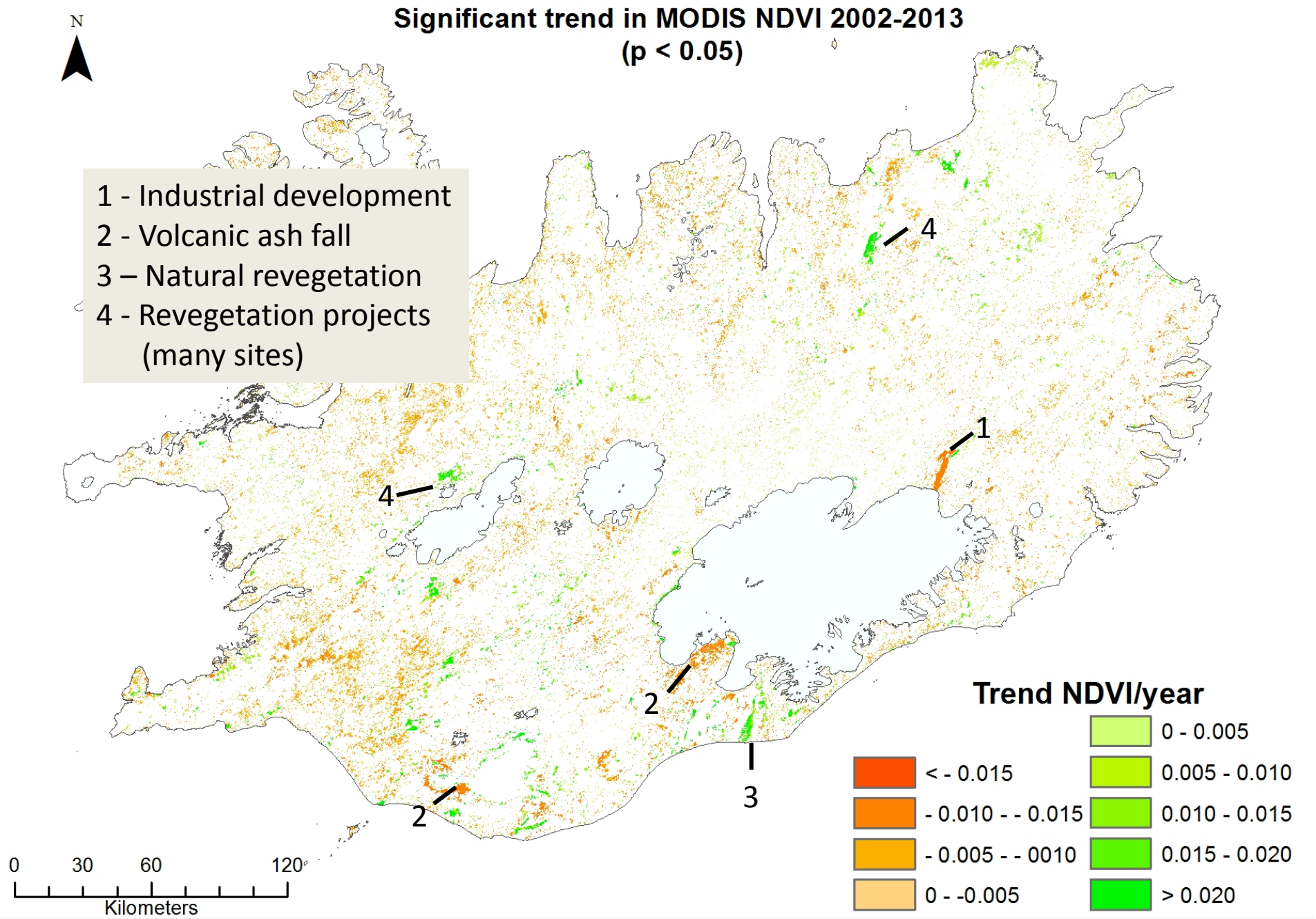
especially hard on evergreen shrubs and ferns

- **Plus pest outbreaks**

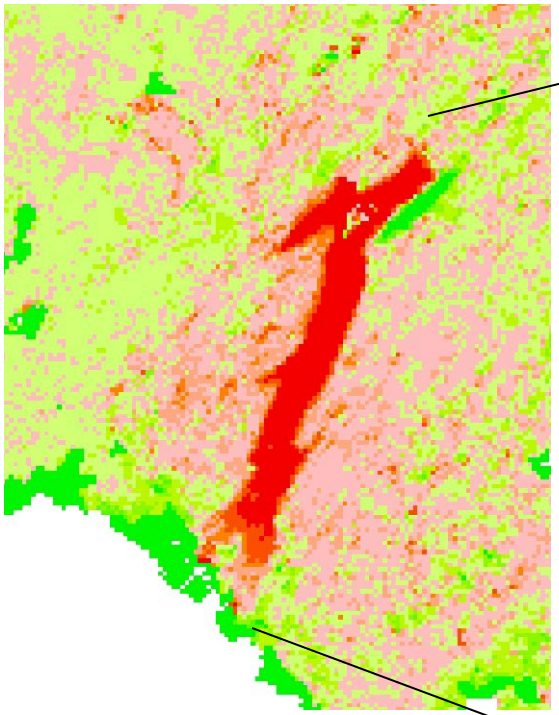


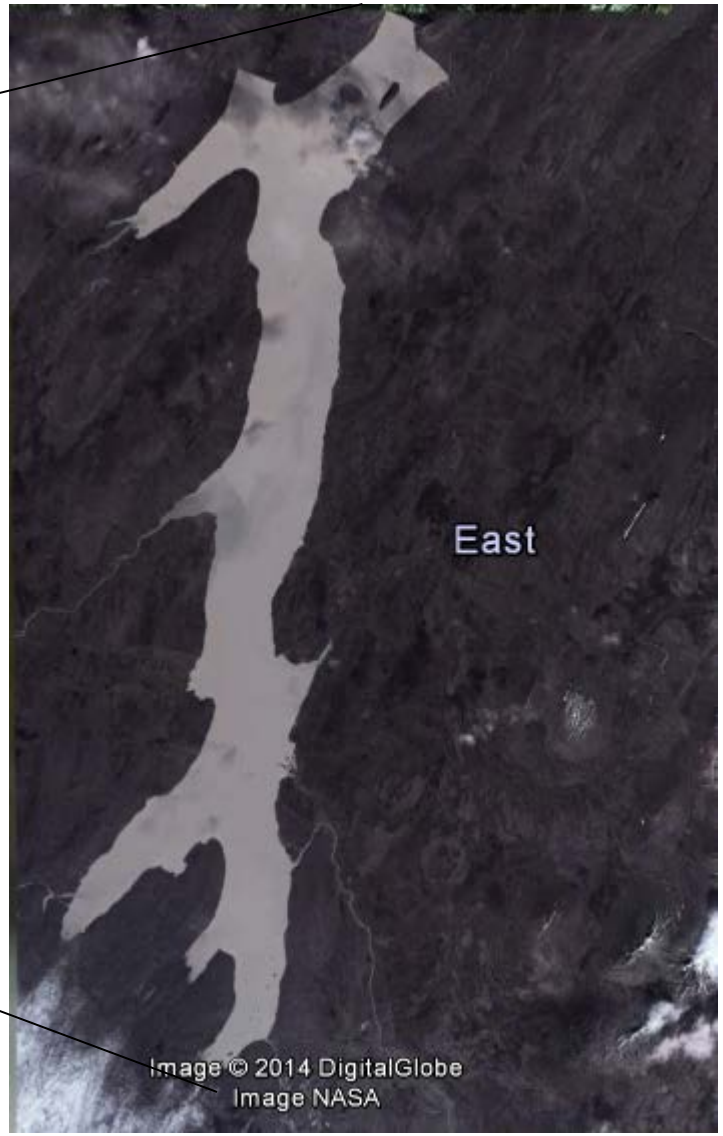
Resulted in record low 2012 NDVI
within decreasing trend

Bjerke et al. 2014 Env. Res. Let.


Significant trend in MODIS NDVI 2002-2013
(p < 0.05)
N
1 - Industrial development
2 - Volcanic ash fall
3 – Natural revegetation
4 - Revegetation projects
(many sites)
1
2
2
3
4
4
Trend NDVI/year
< - 0.015
- 0.010 - - 0.015
- 0.005 - - 0010
0 - -0.005
0 - 0.005
0.005 - 0.010
0.010 - 0.015
0.015 - 0.020
> 0.020
0
30
60
120
Kilometers

Kárahnjúkar Hydropower Reservoir

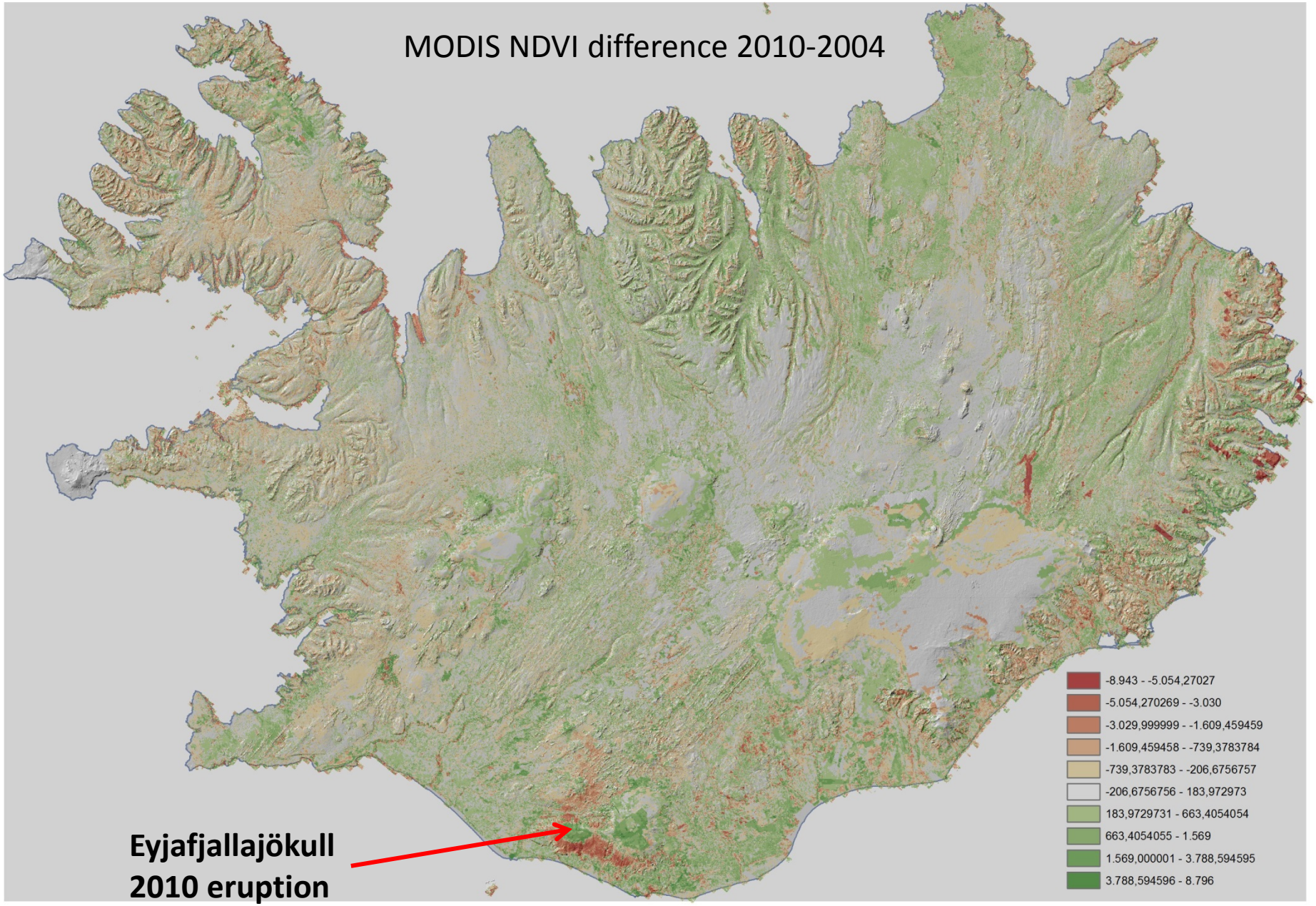




Construction 2002-2008

Kárahnjúkar Hydropower Reservoir

photo "KH2007-07-17-3423KDsouth" by OddurBen


MODIS NDVI difference 2010-2004
-8.943 - -5.054,27027
-5.054,270269 - -3.030
-3.029,999999 - -1.609,459459
-1.609,459458 - -739,3783784
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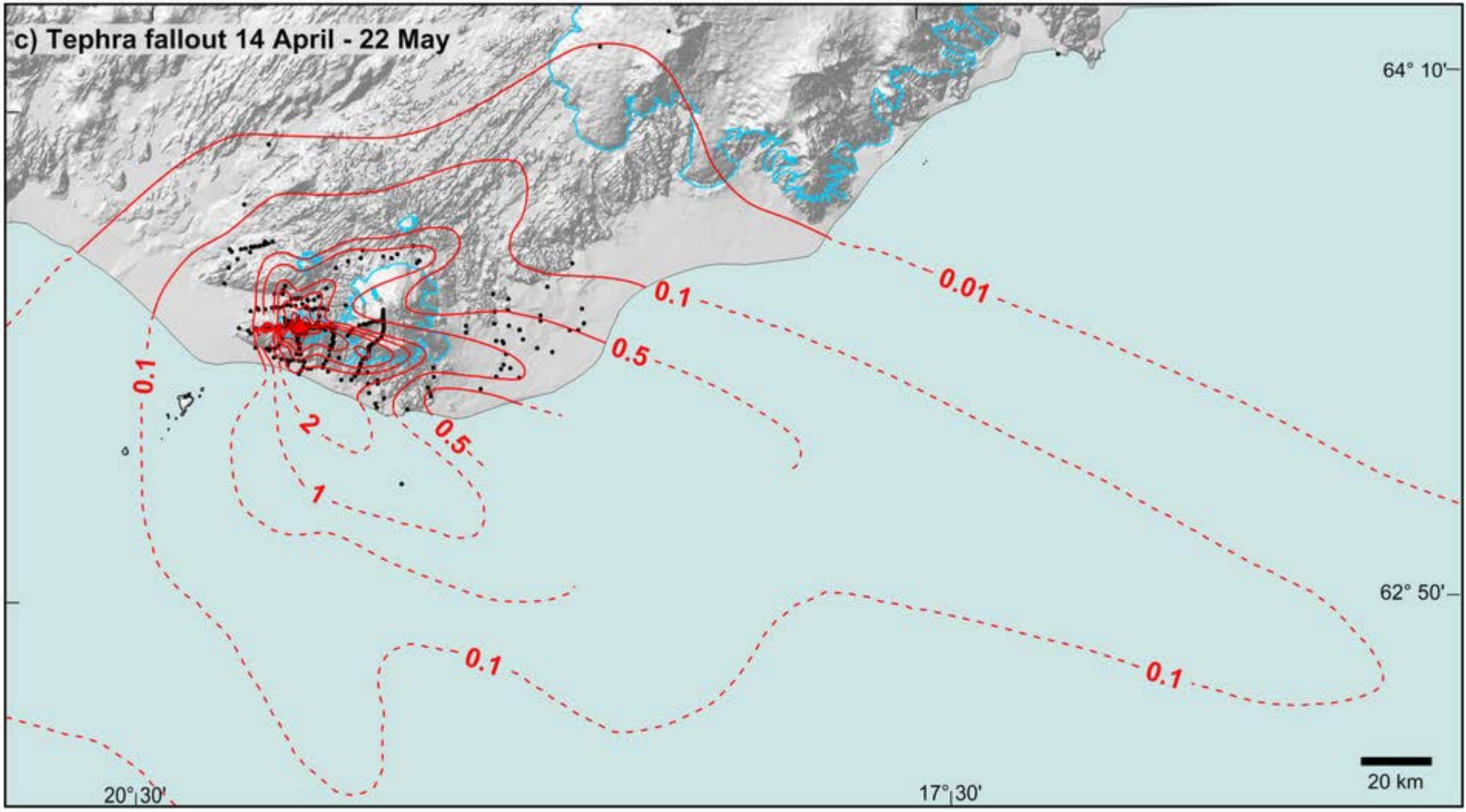
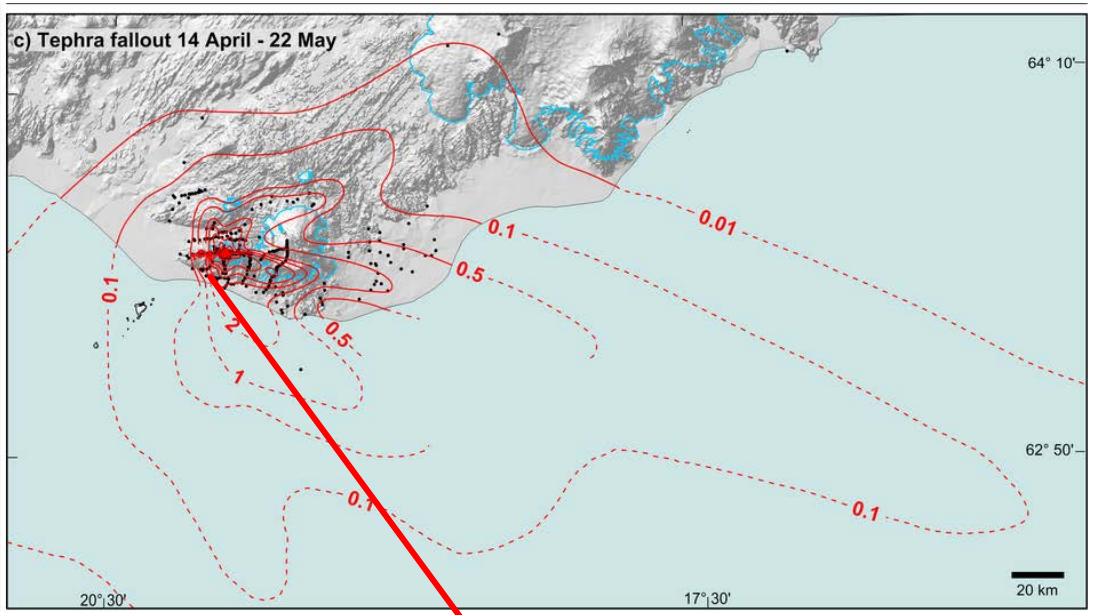
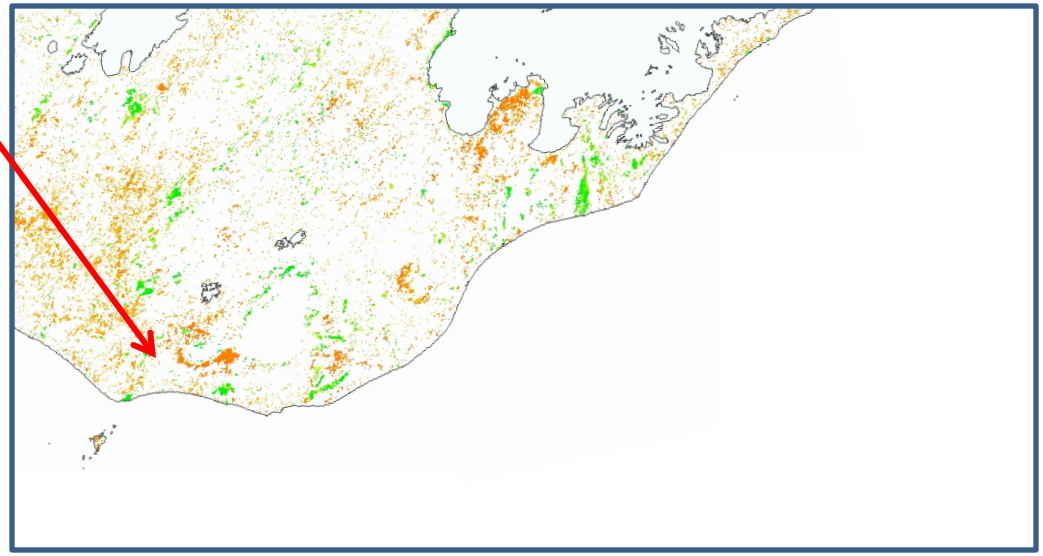
183,9729731 - 663,4054054
663,4054055 - 1.569
1.569,000001 - 3.788,594595
3.788,594596 - 8.796
Eyjafjallajökull
2010 eruption



Ash fall from 2010 Eyjafjallajökull eruption

Gudmusson et al. 2011. Nature Scientific Report 2: 572 doi:10.1038/srep00572


c) Tephra fallout 14 April - 22 May
64° 10'
62° 50'
20°|30'
17°|30'
20 km
0.01
0.1
0.5
1
2
0.1
0.1
0.1
0.5



Eyjafjallajökull eruption 2010

Images are from the Þórsmörk area to the north of the glacier

Borgþór Magnússon June 16, 2010

Eyjafjallajökull eruption 2010

Images from the Skógar area uplands to the south of the glacier that received the heaviest ashfall

Borgþór Magnússon June 7, 2010

2010 6 7

2010 6 7

2010 6 7

2010 6 7

Grímsvötn eruption 2011

Images from Fljótshverfi, southeast of the glacier Vatnajökull

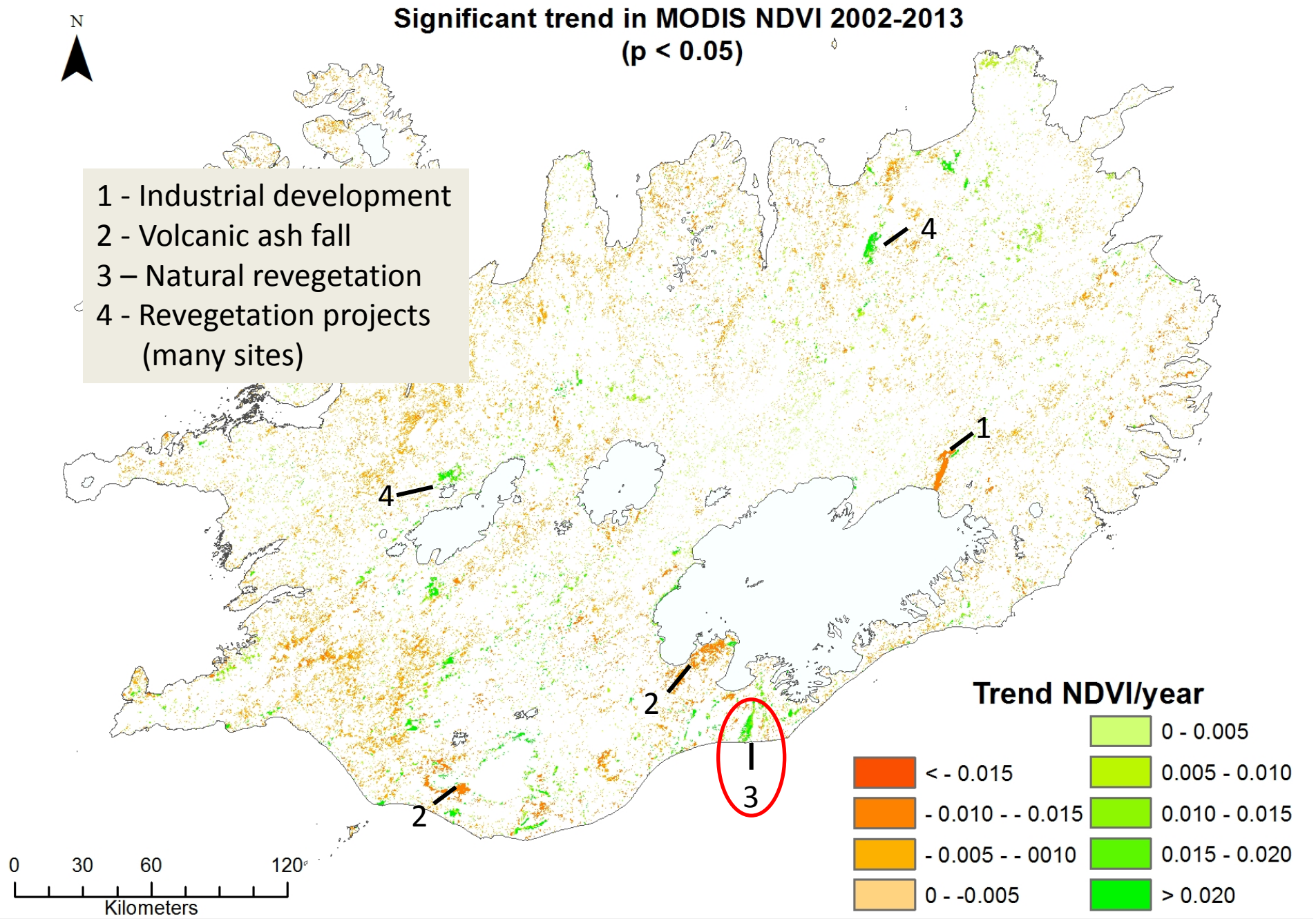
Sigurður H. Magnússon May 31, 2011

Brunahraun, Racomitrium moss lava

Mountain birch

Mountain birch

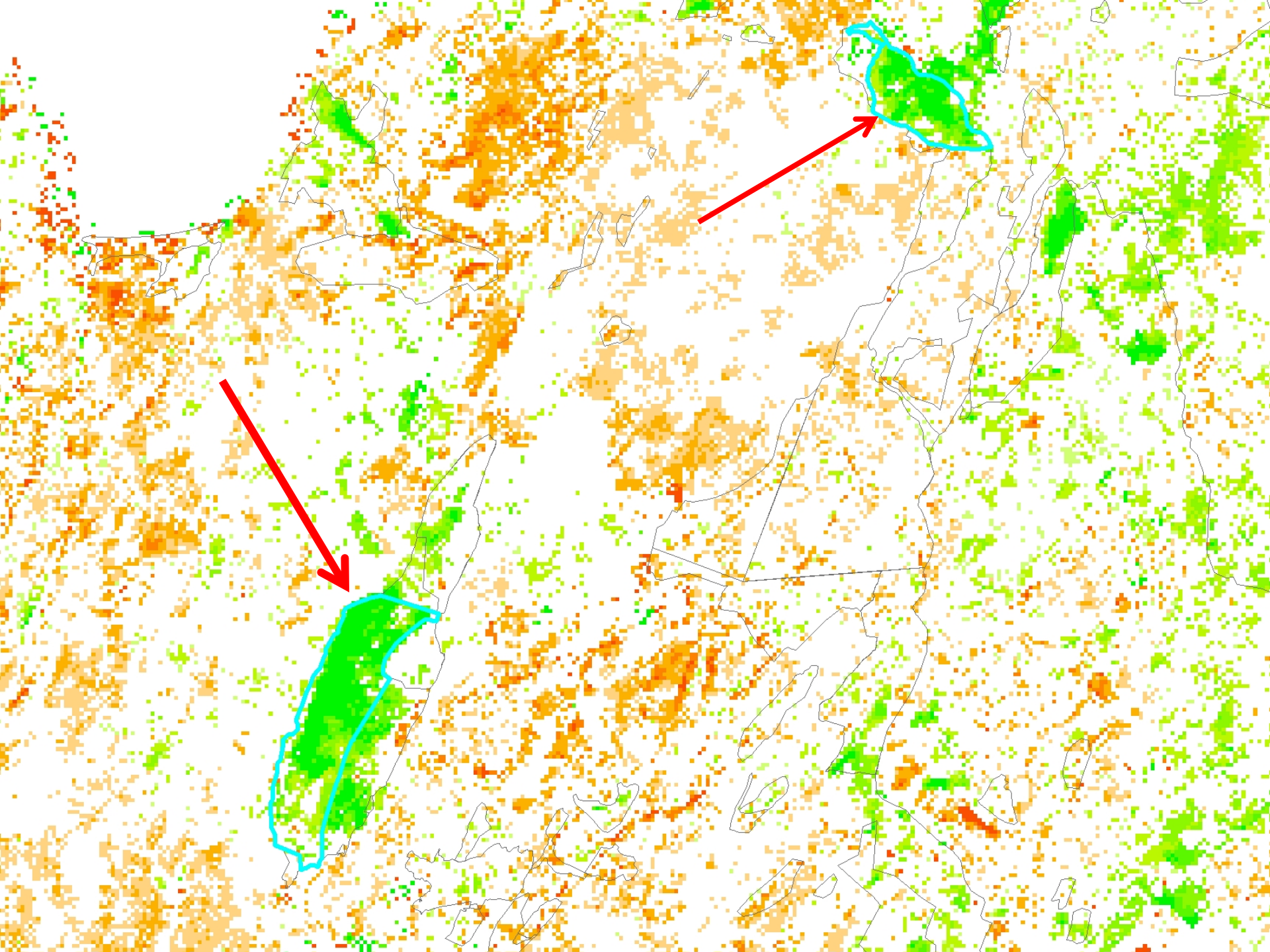
The farm Seljaland

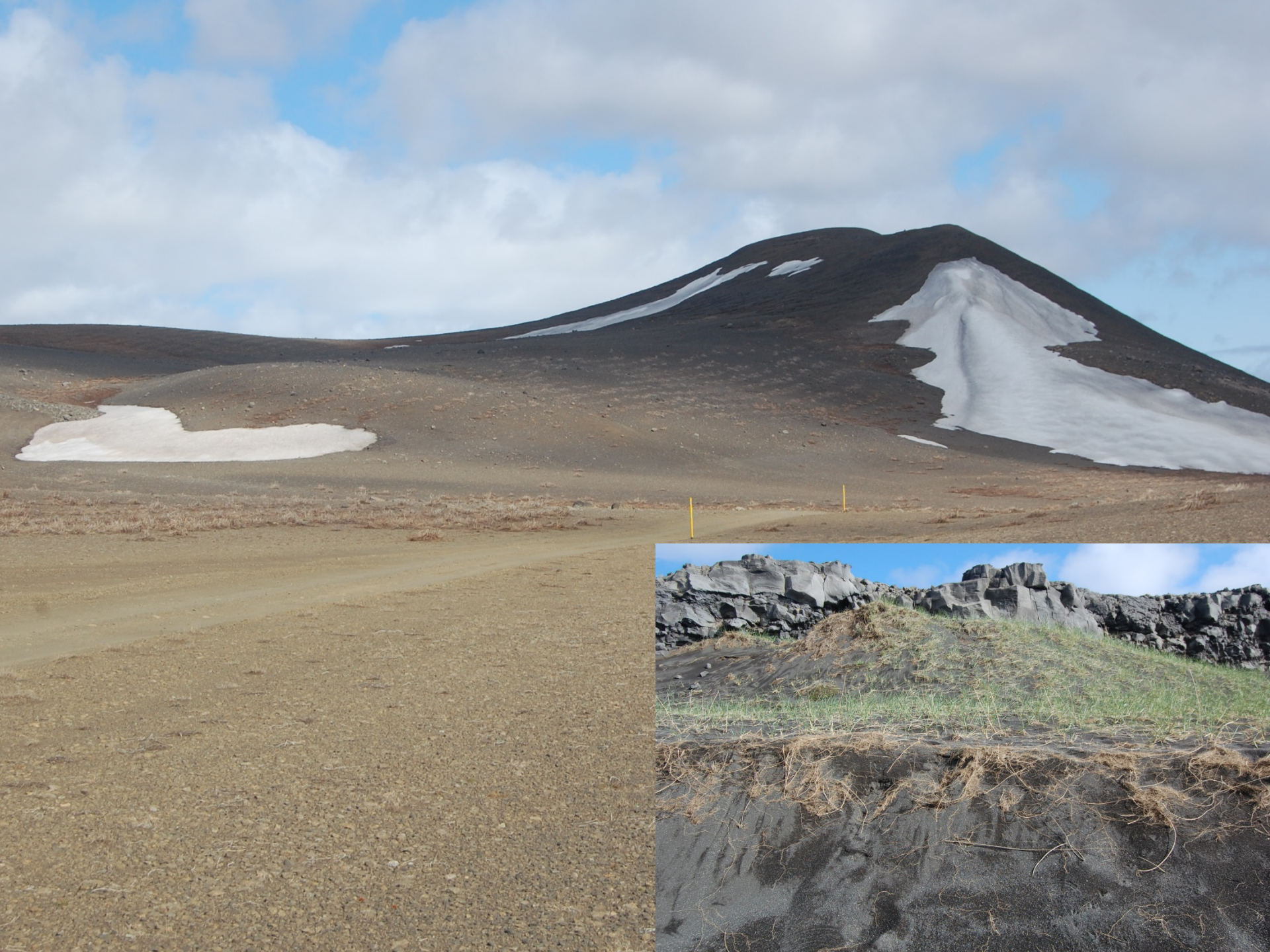

Significant trend in MODIS NDVI 2002-2013
(p < 0.05)
N
1 - Industrial development
2 - Volcanic ash fall
3 – Natural revegetation
4 - Revegetation projects
(many sites)
4
1
4
2
3
2
Trend NDVI/year
< - 0.015
- 0.010 - - 0.015
- 0.005 - - 0010
0 - -0.005
0 - 0.005
0.005 - 0.010
0.010 - 0.015
0.015 - 0.020
> 0.020
0
30
60
120
Kilometers

Natural revegetation sandur

Greening in reclamation areas, where beach grass (*Leymus*) and/or lupine (*Lupinus nootkatensis*) has been seeded and is expanding:

- Hills in the uplands of Reykjavik (lupine expansion),
- Bakki harbour reclamation area on the south coast, extensive seeding of *Leymus* (the area to the northeast of Vestmannaeyjar)
- Sólheimasandur (southeast of Eyjafjallajökull), reclamation with lupine, expanding greatly during the period
- Mýrdalssandur (southeast of Mýrdalsjökull), reclamation along highway, *Leymus* and lupine
- Hólasandur and Ássandur in northeast Iceland - extensive reclamation areas with lupine and lesser extent grass seeding
- Blöndulón reservoir north of Langjökull - reclamation with grasses
- Haukadalsheiði to the south of Langjökull - reclamation with lupine and some grass seeding

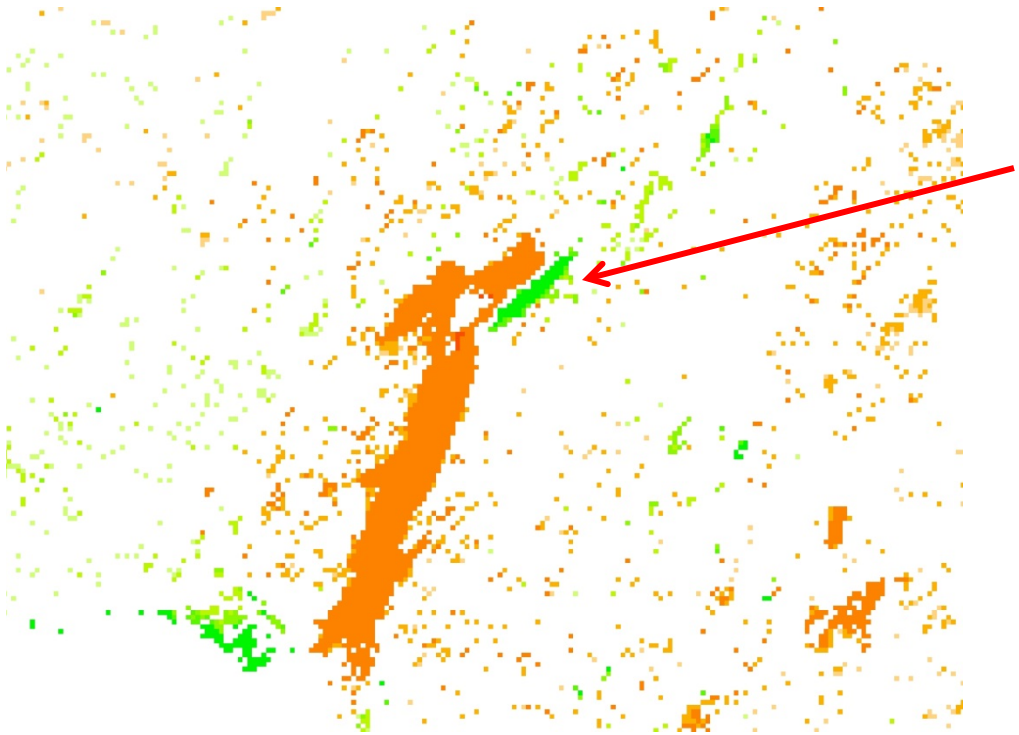


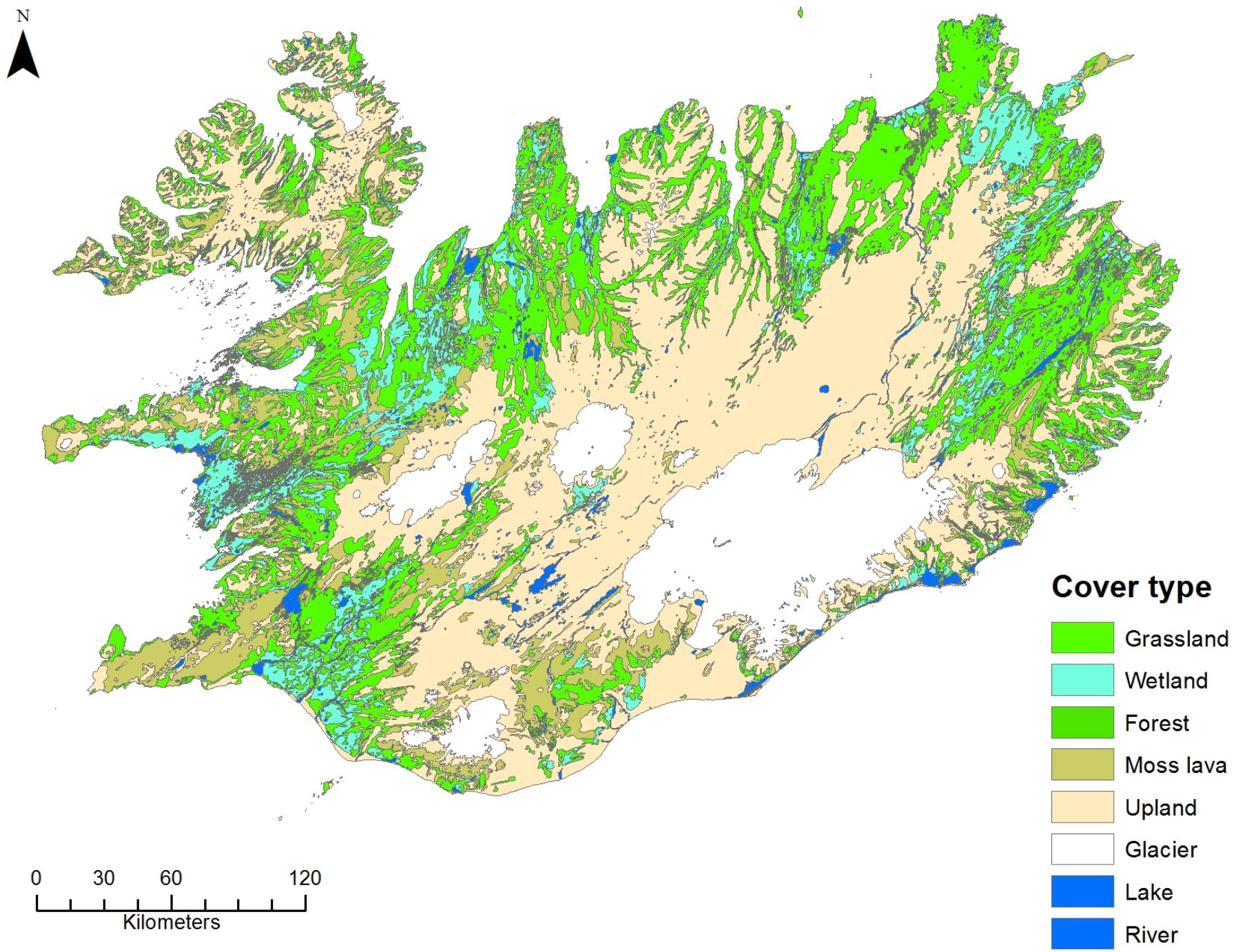


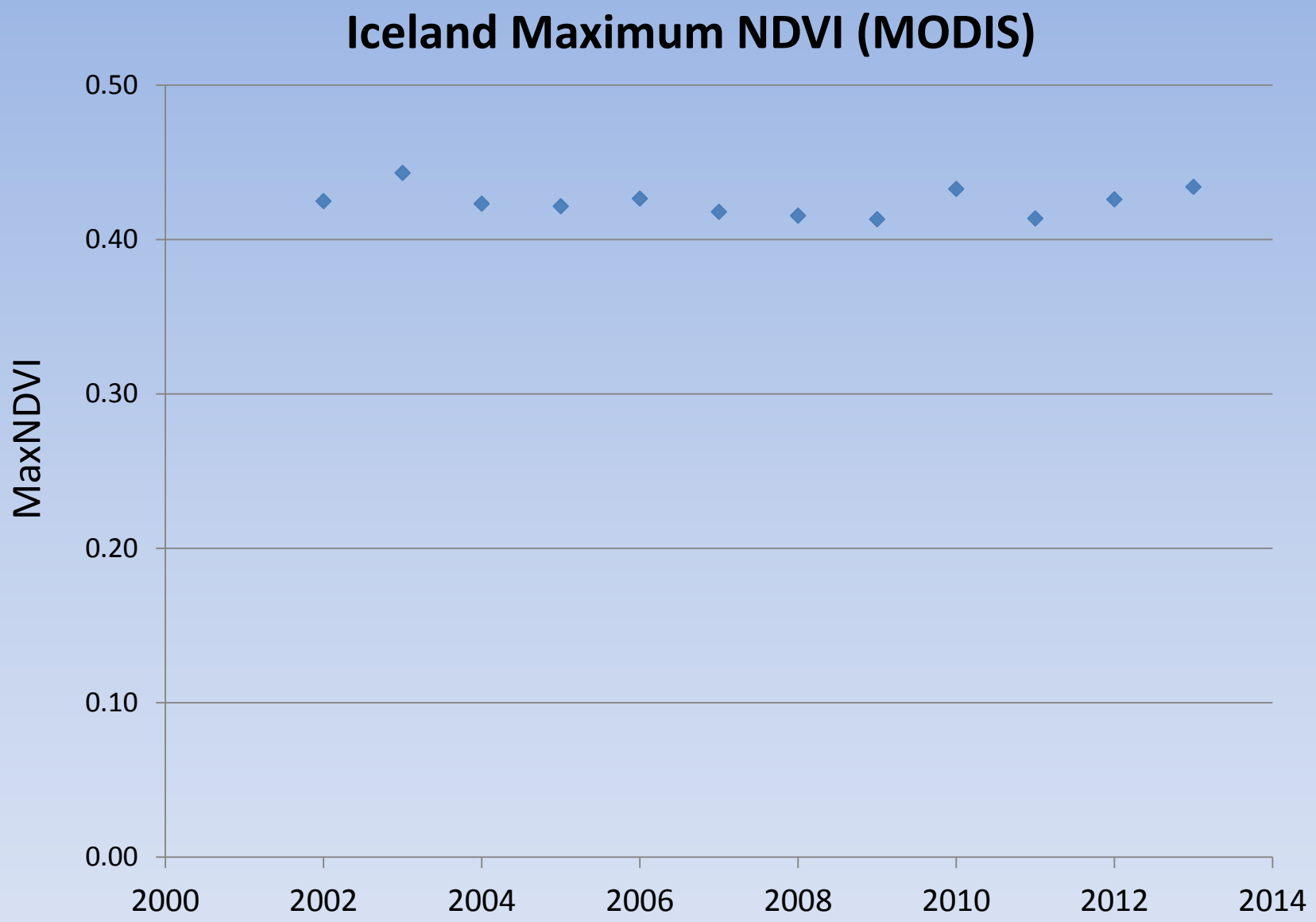
Dimmuborgir, Mývatn area

Reclamation area east of Hálslón reservoir

Sigurður H. Magnússon August 13, 2014




N
0
30
60
120
Kilometers
Cover type
Grassland
Wetland
Forest
Moss lava
Upland
Glacier
Lake
River



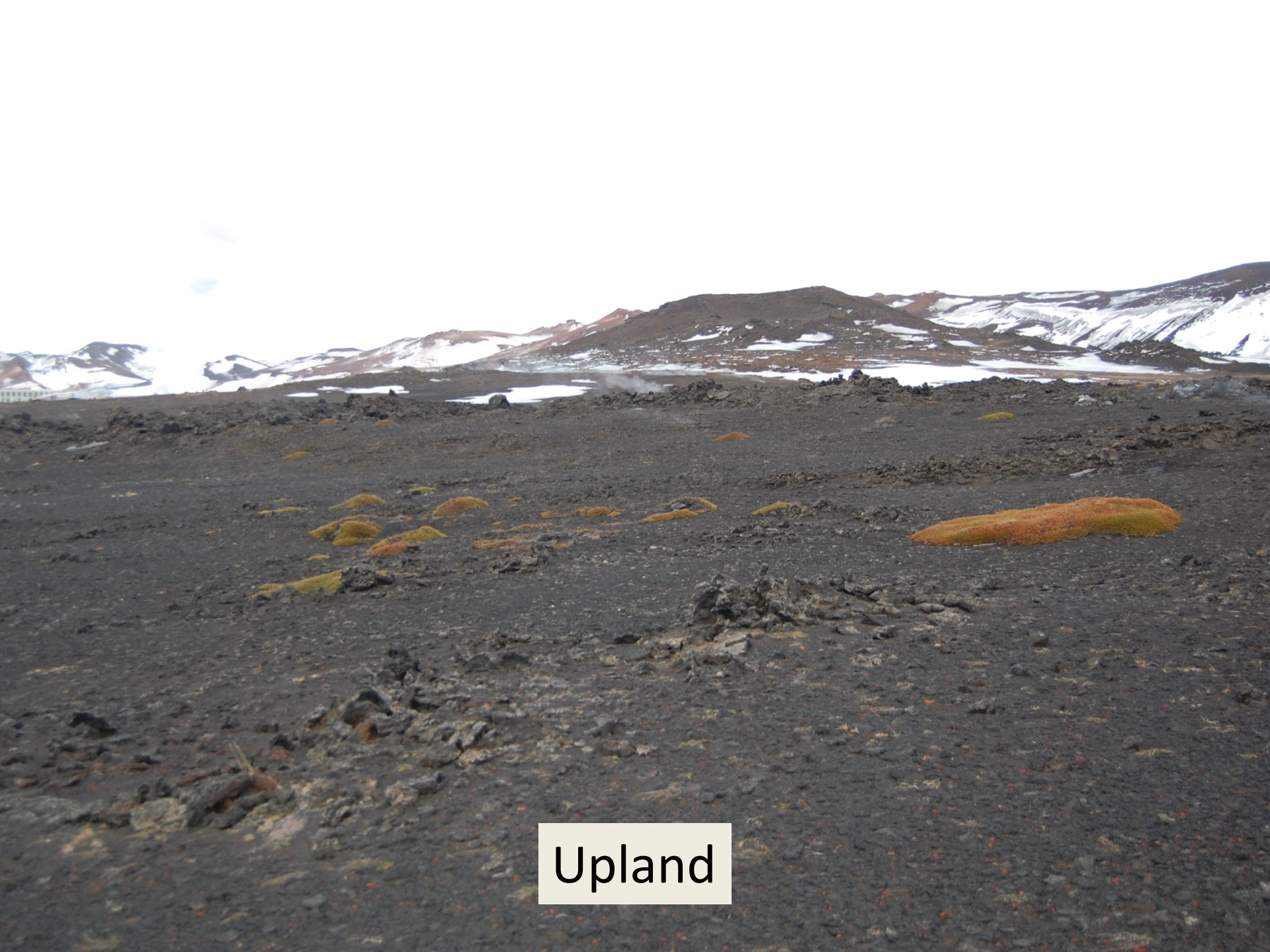
weighted average based on 5 vegetation types, to minimize effect of cloud cover

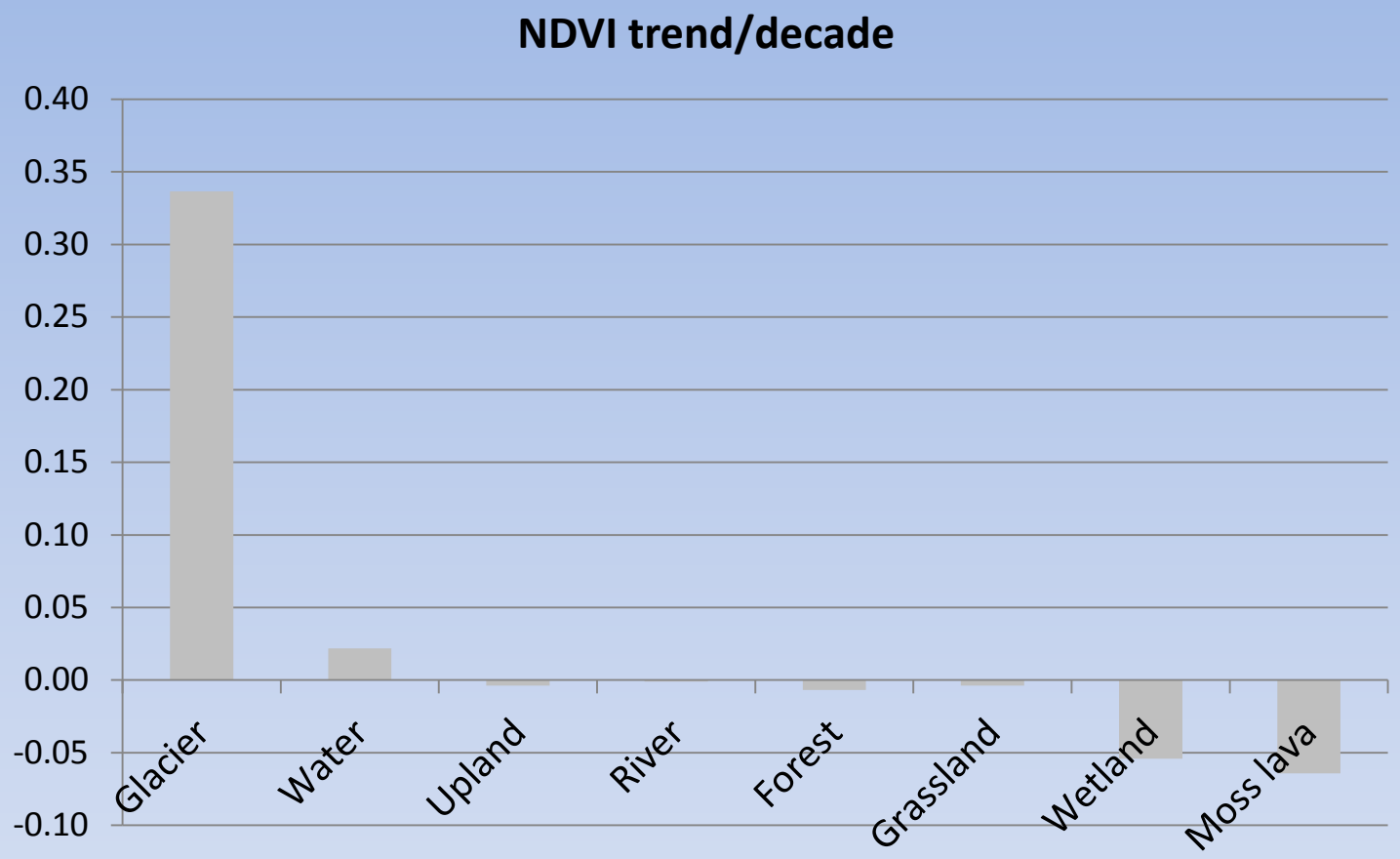
Grassland

Wetland

Forest

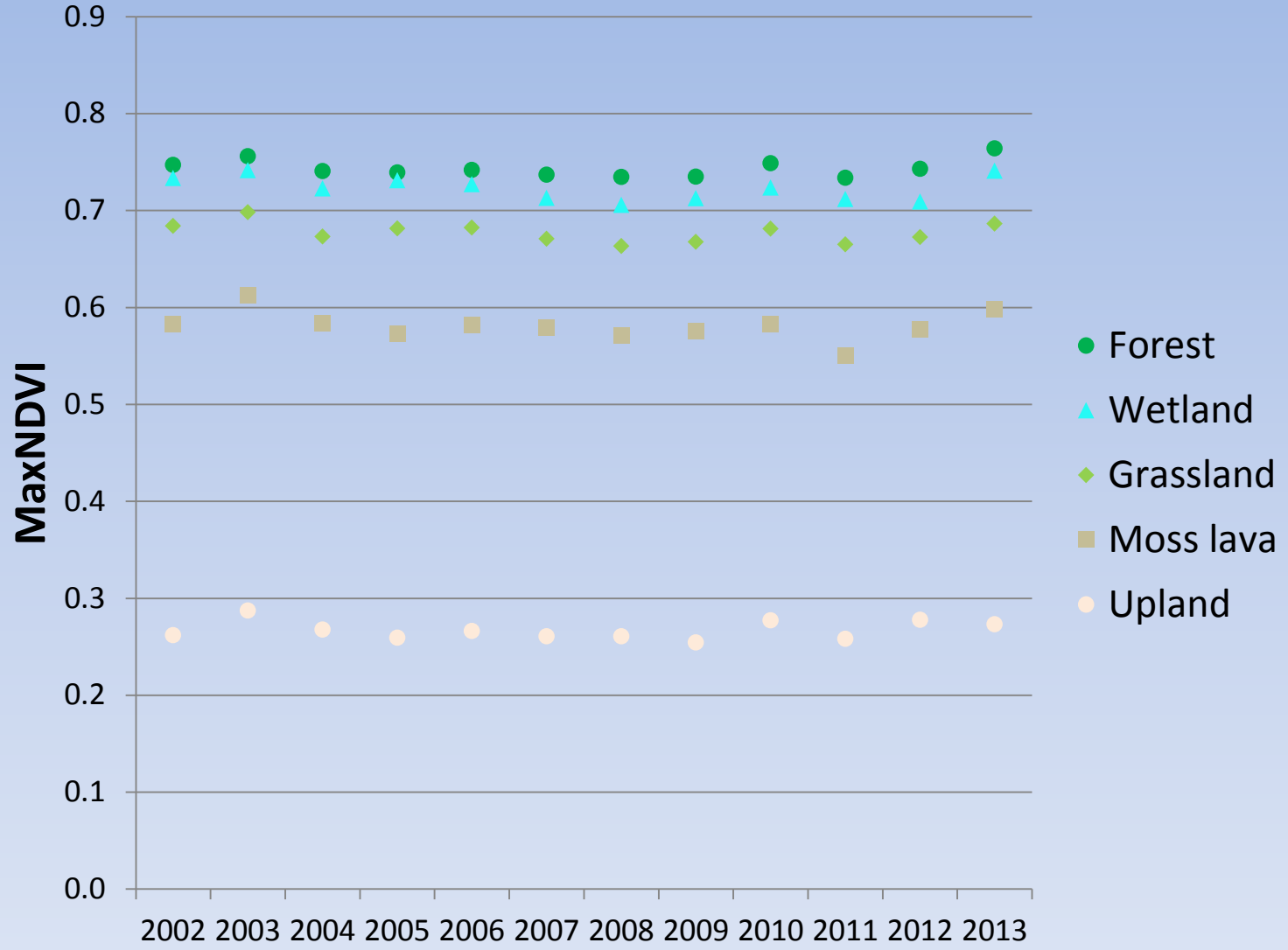
Moss-lava


Upland



By elevation classes, only areas > 900 m showed positive trends in NDVI

MODIS maxNDVI for Iceland vegetation types



Conclusions

- Major changes in vegetation that occur during the time period of the data show up well.
    - Good tool for monitoring episodic events like volcanic activity or on-going efforts such as revegetation
- Overall trend for whole country over such a short time period not particularly useful.

Questions

At what scale, temporal and spatial, do NDVI trends provide the most useful, reliable, data?

Is hand-held NDVI most reliable and repeatable?

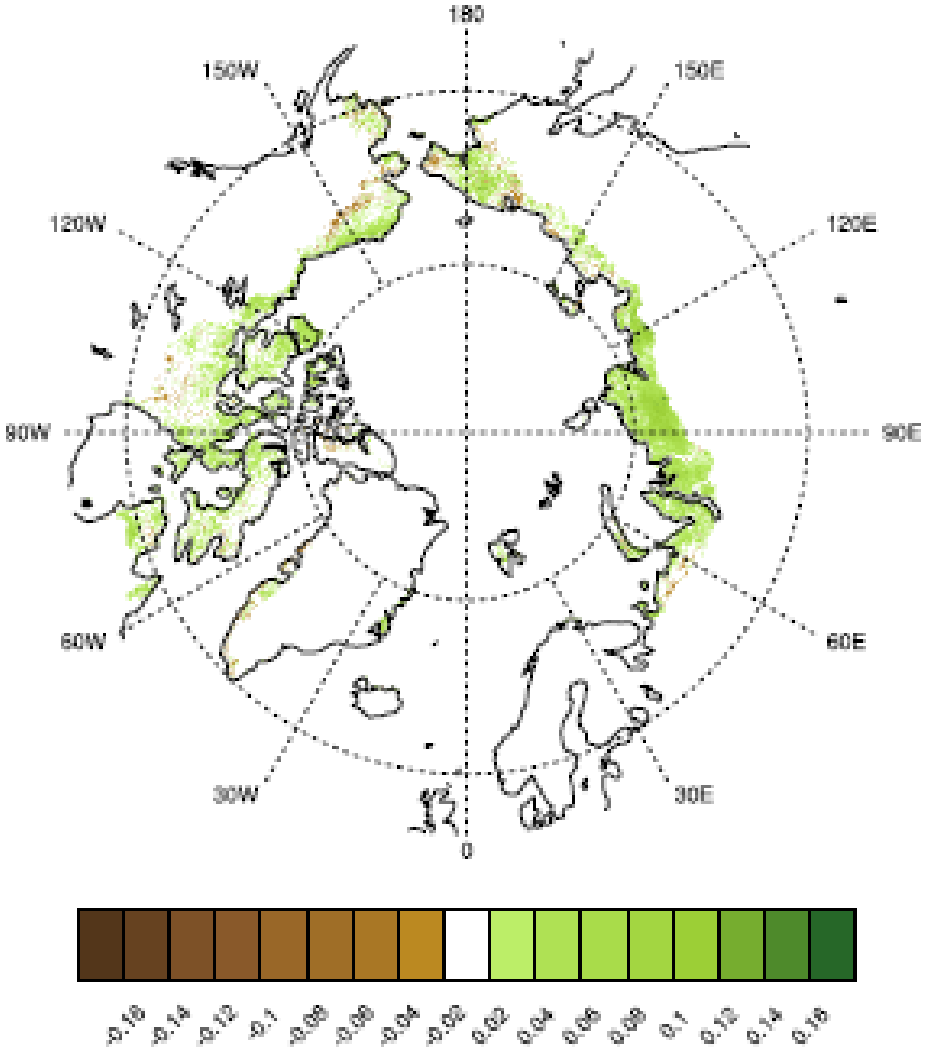
Or is coarse satellite imagery with many overflights per day more reliable?

Non-vegetative effects

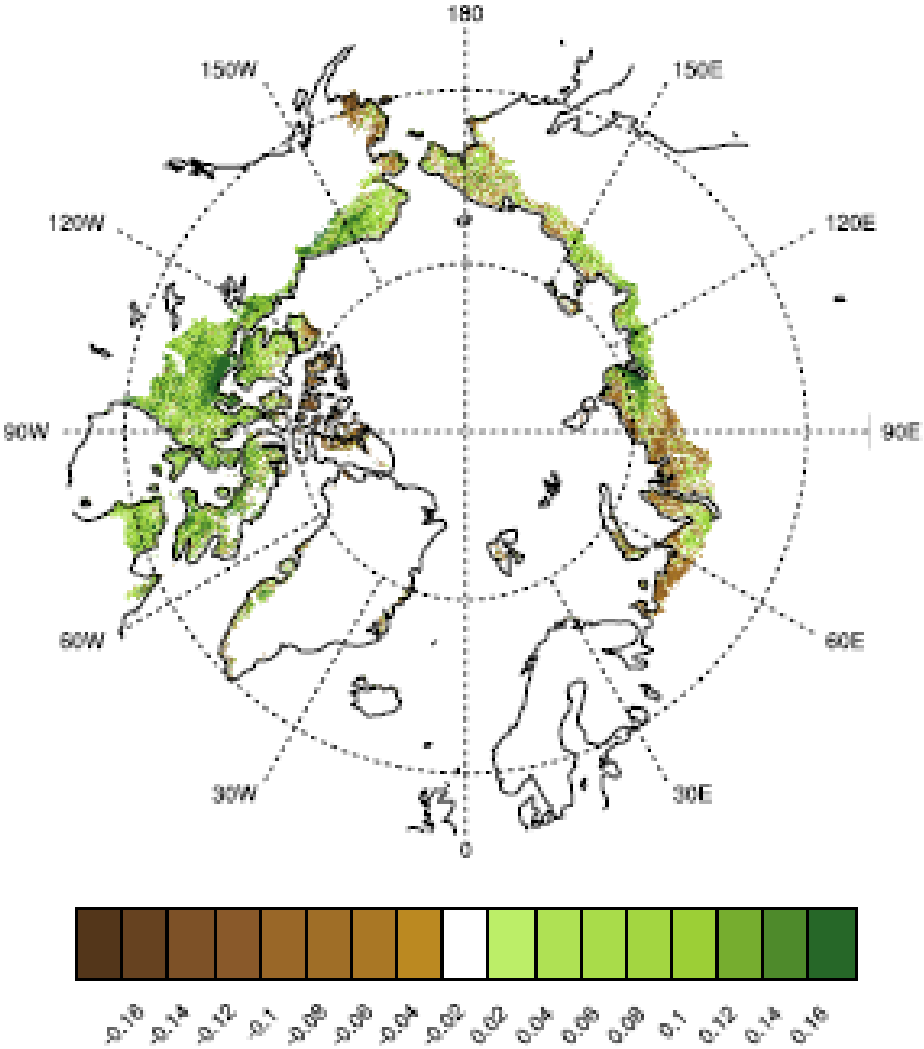
lichen cover

water cover

MaxNDVI 82-98



MaxNDVI 99-13



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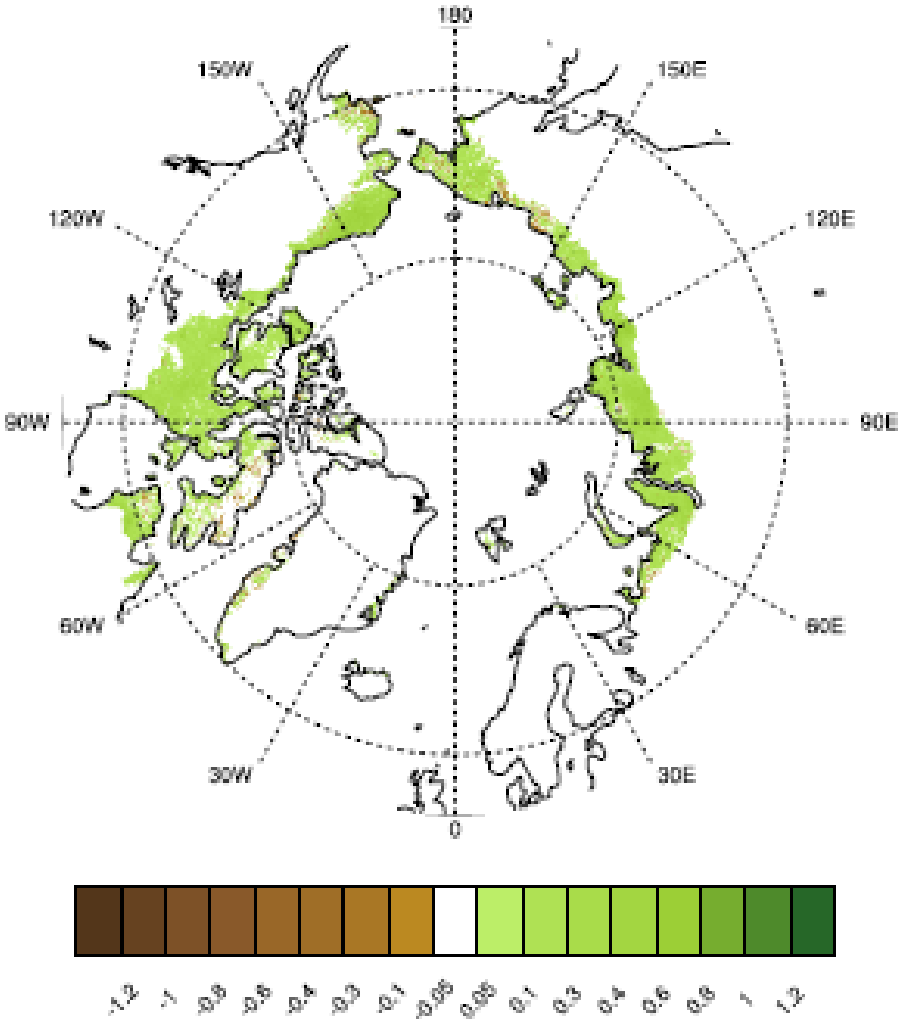

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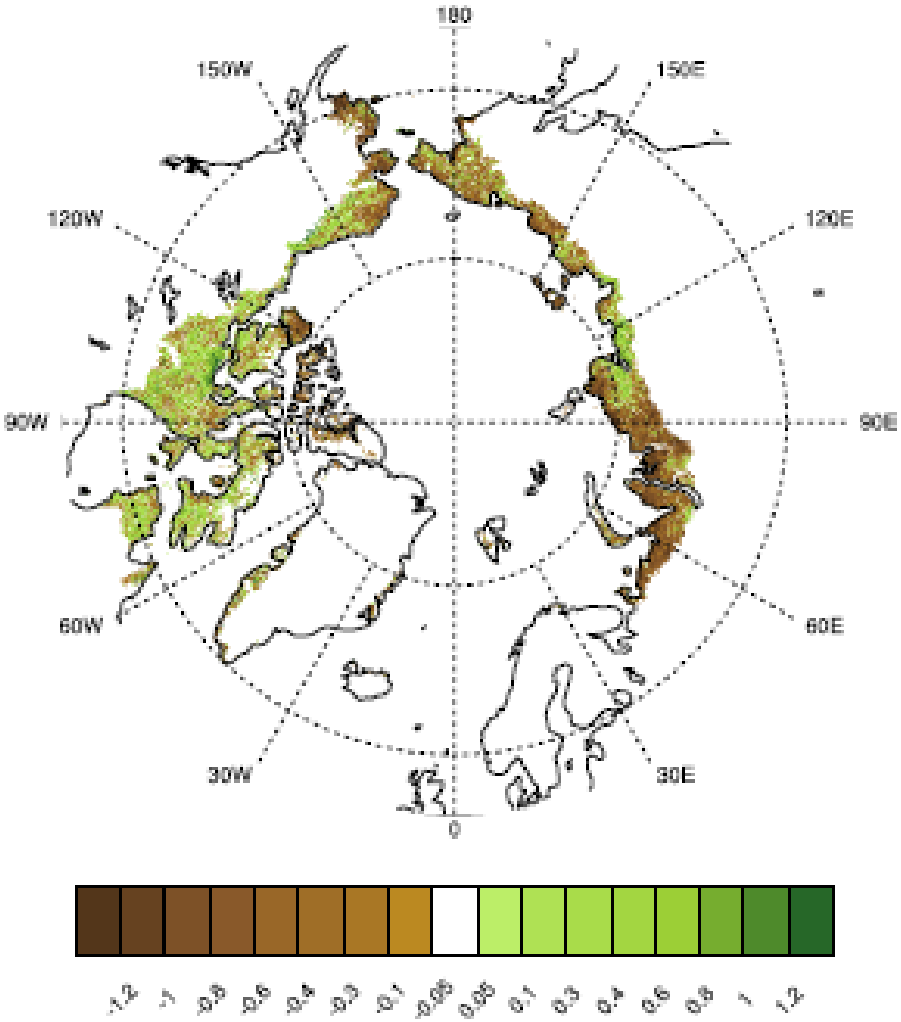

Takk Fyrir!

Questions?

Photo - M.K. Raynolds